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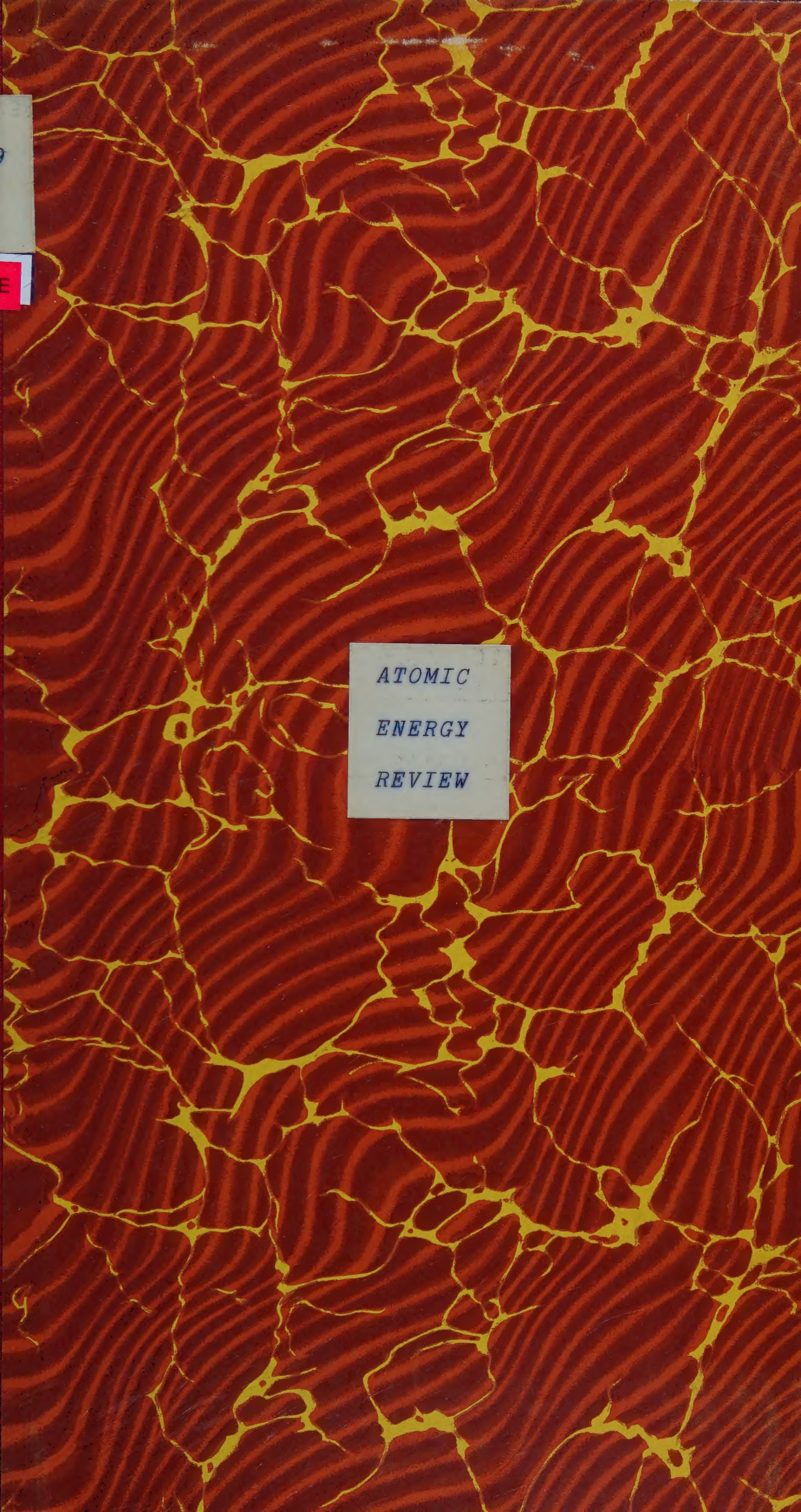

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ATOMIC ENERGY REVIEW

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МЕЖДУНАРОДНОЕ АГЕНТСТВО ПО АТОМНОЙ ЭНЕРГИИ – ВЕНА, 1970
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The Agency's Statute was approved on 23 October 1956 by the Conference on the Statute of the IAEA held at United Nations Headquarters, New York; it entered into force on 29 July 1957. The Headquarters of the Agency are situated in Vienna. Its principal objective is "to accelerate and enlarge the contribution of atomic energy to peace, health and prosperity throughout the world".

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July 1970

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REVUE D'ENERGIE ATOMIQUE
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ORGANISMO INTERNACIONAL DE ENERGIA ATOMICA - VIENA, 1970

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FOREWORD

The Cumulative Index to the Atomic Energy Review covers volumes 1-7 (1963-1969), the Commemorative Issue (1966), and the Special Issues No. 1 (1966) and No. 2 (1968). This edition supersedes the Cumulative Index, Vols. 1-3 (1963-1965). Starting with Vol. 8 the title and author indexes will appear in the last issue of each volume.

The section "Abstracts of papers" has been arranged alphabetically by author and co-author, thus no separate author index is given. In an attempt at a uniform presentation of the affiliations, the TID-5059 (9th Rev.) report "Corporate Author Headings used by the U.S. Atomic Energy Commission in Cataloguing Reports" was used as a basis. In another deviation from the original, all Russian authors who have been working at the Agency are cited with two initials.

Please forward all correspondence in connection with this index to the Editor, Atomic Energy Review, International Atomic Energy Agency, Kärntner Ring 11, P.O. Box 590, A-1011 Vienna, Austria.

ABSTRACTS OF PAPERS

ATOMIC ENERGY REVIEW, Vols. 1-7

1 Adams, F. (Ghent Rijksuniversiteit (Belgium). Instituut voor Kernwetenschappen).
FABRICATION, PROPERTIES AND APPLICATIONS OF Ge(Li) GAMMA DETECTORS.
Vol. 5, No. 4 (1967) p. 31-92.

Gamma-ray spectrometry has progressed rapidly as a result of the development of lithium-drifted germanium detectors. In both pure nuclear research and in applied spectrometry the excellent resolution and the good detection efficiency of these devices is now fully recognized. This paper describes the fabrication of detectors of different types, such as planar and coaxial, taking into account the practical difficulties such as lithium precipitation, drift failure, and surface leakage current. The instrumentation including preamplifier, amplifier, analysing equipment, and the problems associated with very high resolution spectrometry, are briefly reviewed. The characteristics of different types of detectors, such as energy and time resolution and detection efficiency, are mentioned. A number of applications in analytical and radiochemistry are discussed. These include activation analysis, X-ray fluorescence analysis, and fission-product studies.

2 Adams, F., Hoste, J. (Ghent Rijksuniversiteit (Belgium). Instituut voor Kernwetenschappen).
NON-DESTRUCTIVE ACTIVATION ANALYSIS.
Vol. 4, No. 2 (1966) p. 113-180.

Non-destructive activation analysis is based on specific irradiations or measurements. The paper describes various ways in which activation can be performed, e.g. with nuclear reactors, neutron generators and isotopic sources. It deals with direct measurement by gamma spectroscopy and various more specialized methods, notably using Compton subtraction, special detectors, coincidence counting and a data processing machine. Irradiation with charged particles, protons, deuterons, alpha-particles or ^{3}He ions affords a means of analysing surfaces, while gamma rays have certain advantages for elements of low atomic number. A survey of the work done in this field is provided in the form of a bibliography of applications of instrumental activation analysis, based on references in the literature for the period 1960-1965.

3 Agranenko, V.A. (International Atomic Energy Agency, Vienna (Austria)), Révész, L. (Karolinska Institutet, Stockholm (Sweden)).
THE INITIAL EFFECTS OF IONIZING RADIATIONS ON CELLS.
Report on the 2nd International Symposium held at Yerevan, USSR, 29 October - 3 November 1968.
Conferences and Symposia.
Vol. 7, No. 2 (1969) p. 225-230.

4 Antoni, F., Kozinets, G.I. (International Atomic Energy Agency, Vienna (Austria)), Koeteles, G. (Institute of Radiobiology, Budapest (Hungary)).
RADIATION STERILIZATION IN MEDICINE — PRESENT APPLICATIONS AND FUTURE PROSPECTS.
Vol. 4, No. 3 (1966) p. 39-61. (In Russian)

The paper summarizes the latest data on the use of ionizing radiation for sterilization purposes in medicine. It is shown that the radiation sterilization of medical instruments and dressings has passed the experimental stage and can now be applied in practice. The use of ionizing radiation to sterilize biological tissue, synthetic materials and a number of medicines which cannot be subjected to heat or chemical sterilization has a promising future.

Appelman, E.H.
see Malm, J.G.: 62

Attree, P. M.
see Hanna, G. C.: 41
see Westcott, C. H.: 101

5 Balashov, V. V. (Moscow State Univ. (USSR). Inst. for Nuclear Physics), Eramzhyan, R. A. (Joint Inst. for Nuclear Research, Dubna (USSR)).
MUON CAPTURE BY NUCLEI AND PROBLEMS OF WEAK INTERACTIONS.
Vol. 5, No. 3 (1967) p. 3-118.

The present review is a systematic summary of the problems of nuclear muon capture. The authors discuss the general ideas on which the effective Hamiltonian of the weak muon-muon interaction is based and also the main trends in experimental studies on muon capture. They analyse the reliability of various nuclear models and meson-capture mechanisms used in calculating the nuclear matrix elements. They consider the possibility of dispensing with nuclear models and adopting a phenomenological approach to muon-capture theory. Experimental projects are proposed.

6 Barrada, Y. (International Atomic Energy Agency, Vienna (Austria)).
THE NEUTRON MOISTURE METER AND ITS VALUE IN WATER-USE EFFICIENCY STUDIES.
Current Research and Development.
Vol. 3, No. 2 (1965) p. 195-212.

Low average crop yields throughout the world are matters of concern in agriculture. Water shortage, especially at critical periods of crop growth, is the main contributing factor. Water-use efficiency studies will provide quantitative estimates of irrigation water required at various periods of crop growth to ensure good and economic yields. Such studies involve knowledge of several factors, of which soil moisture content was most difficult to measure. The neutron moisture meter is able to give results of the necessary accuracy as it measures large volumes of soil in situ and at any chosen depth. The device is based on the relative effectiveness of hydrogen (in the water) in moderating neutrons as compared to the usual elements present in dry soils; the slow neutrons scattered back to the detector are a measure of the soil moisture content. The author discusses the principles of the neutron moisture meter, the neutron source, the relative merits of some of the commonly used detectors (BF_3-tubes, crystal scintillators, etc.), and then goes on to review the practical realization of the device. Brief indications are given as to how its results will provide information on soil variation with depth, the depth of the active root system, soil moisture content, field capacity and irrigation water requirements.

7 Becker, K. (Kernforschungsanlage, Jülich (West Germany)).
RADIOPHOTOLUMINESCENT DOSIMETRY.
Vol. 5, No. 1 (1967) p. 43-95.

The development and present status of silver-activated radiophotoluminescent phosphate glasses, their dosimetric properties, and their application, are reviewed on the basis of more than 300 articles, reports, lectures, patents, expertises, etc., which have been written since 1948. After a brief historical survey the theory of radiophotoluminescence (RPL) and the main general characteristics of dosimeter glasses, such as different aspects for the choice of optimal glass composition, are briefly discussed. Also surveyed are the basic dosimetric properties of RPL glasses of different composition – in particular the kinetic behaviour (build-up and fading), dose range, accuracy, effect of dose-rate, LET, temperature and light; the particular problems of X- and gamma-ray dosimetry (energy and directional dependence); the dosimetry of corpuscular radiation (thermal and fast neutrons, electrons and charged particles); the applications of glass dosimeters in personnel dosimetry (badge design, organization, etc.); special applications, for example, for radiobiological and medical dosimetry; and the design of readers. Finally, the relative advantages and disadvantages of glass dosimeters are compared with other systems (film, TLD). An almost complete list of references is given.

8 Běhounek, F. (Československá Akademie Věd, Řež. Ústav Jaderného Výzkumu).
RECENT PROGRESS IN DOSIMETRY OF IONIZING RADIATIONS.
Vol. 1, No. 2 (1963) p. 37-97.

The paper considers all methods of measuring ionizing radiation which have been developed during the past few years, i.e. the ionization chamber method, counting, chemical, photographic, colorimetric, luminescent and calorimetric methods. Special attention is devoted to those dosimetric methods which have been studied more extensively – scintillation spectrometry, semiconductor detectors, luminescent chambers and spark chambers. In the last section some other methods are briefly mentioned together with the re-determination of some basic values and calibration and correction procedures. In conclusion the most important progress achieved to date is reviewed and those fields where further improvement is most necessary are discussed.

9 Belov, V. F., Zheludev, I. S. (Akademiya Nauk SSSR, Moscow. Institut Kristallografii).
APPLICATION OF THE MÖSSBAUER EFFECT TO THE STUDY OF FERRITES AND DIELECTRICS.
Vol. 5, No. 4 (1967) p. 3-30.

The paper reviews the results of studies on the Mössbauer effect in ferrites with garnet and spinel structures and also in various dielectrics. Using ferroelectrics and ferromagnetics as examples, it is shown that the Mössbauer effect may be successfully used in phase transition studies. In the phase transition region the probability of the Mössbauer effect shows anomalous characteristics connected with the anomalous temperature dependence of the frequency of the optical branch of the crystal lattice vibrational spectrum. Along with quadrupole splitting, a magnetic hyperfine structure of the Mössbauer spectra is observed in ferromagnetics, which disappears on transition to the paramagnetic state. In the region of the Curie ferroelectric temperature a sharp change occurs in the chemical shift in $BaTiO_3$ and $Pb(Fe_{0.5}Nb_{0.5})O_3$, indicating a change in the ionic character of the chemical bond. The review quotes the results of studies which do not fit in with these mechanisms. Considering as a concrete example single crystals of tourmaline, opportunities are cited for application of the Mössbauer effect in elucidating structural problems. An important aspect of ferromagnetism is the nature of the magnetic fields at the nuclei. The review gives the results of investigations of Mössbauer spectra in iron garnets and spinels. Analysis of experimental data on the magnetic fields at the nuclei of these compounds shows that the strength of the magnetic field depends on the magnetic moment of the ions, the local environment, and the number and nature of the exchange bonds. In iron garnets account must also be taken of the degree of covalency of the chemical bond and of the deviation of the lattice symmetry from the cubic. The occurrence of magnetic fields at diamagnetic atoms of tin in the lattice of an yttrium iron garnet is described. Magnetic fields at Fe iron nuclei are normally due to the ion's own electrons. In the case of tin, however, the magnetic field is created by polarization of the electron shell of a diamagnetic atom by the magnetic moment of iron atoms, through indirect exchange interaction.

10 Berzin, A. K., Bespalov, D. F., Zaporozhets, V. M., Kantor, S. A., Leipunskaya, D. I., Sulin, V. V., Feldman, I. I., Shimelevich, Yu. S. (Vsesoyuznyi Nauchno-Issledovatel'skii Institut Yadernoi Geofiziki i Geokhimii, Moscow (USSR)).
PRESENT STATE AND USE OF BASIC NUCLEAR GEOPHYSICAL METHODS FOR INVESTIGATING ROCKS AND ORES.
Vol. 4, No. 2 (1966) p. 59-111.

Present trends of development in industry, agriculture and science are characterized by a high consumption of various types of mineral raw material. This has given rise to the need for a systematic increase in the amount of theoretical and applied geological, geochemical and mineralogical work with regard to prospecting, exploring and working deposits of various minerals. As a result, particular importance attaches to the prompt satisfaction of the demands of geology for data on the elemental composition of the rocks and ores studied, and on the occurrence in their strata of various physico-chemical processes connected with the working of mineral raw material deposits. Such tasks can be solved with rapidity, sensitivity and accuracy only by the use of current achievements in methods of analysis and investigation based on the chemical, physical and physico-chemical properties of the rocks and ores. In recent years, as a result of the particularly intensive development of nuclear physics, nuclear-physical methods of analysis and investigation have begun to acquire increasing importance. Standard radioisotope sources are very widely used in nuclear-geophysical practice to log oil, gas, coal and ore boreholes. Logging data serve for the lithological differentiation and correlation of the geological sections of boreholes, for determining the thickness of productive strata, the position of water-oil and gas-liquid contacts, porosity, degree of oil-gas saturation and presence of coal in the rock, and for the quantitative and qualitative assessment of the content of various industrially valuable elements in the strata. Radioisotope sources are also successfully used in various nuclear-geophysical methods of elemental analysis of rock and ore samples, both in laboratory and in field conditions. In recent years nuclear geophysics has begun to make wider use of nuclear reactors, sub-critical reactors and neutron and gamma generators. The potentialities of radioactive logging have been considerably extended by the development of steady-state and pulsed neutron generators specifically intended for nuclear-geophysical borehole work. Particular attention has been paid to the development and industrial application of highly effective pulsed-neutron methods of investigating boreholes. In particular, the use of these methods to determine the position of water-oil and gas-liquid contacts has proved two to three times more effective than the standard methods based on the use of radioisotope neutron sources. A very promising approach is the use of new methods of activation analysis of rocks and ore samples involving fast neutron generators and betatrons. This is beginning to eliminate the long-standing shortcomings in the analysis of samples for light elements, and also fulfils important prerequisites for the non-destructive multi-component analysis of samples.

Bespalov, D. F.
see Berzin, A. K.: 10

11 Beswick, C. K., Cameron, J. (International Atomic Energy Agency, Vienna (Austria)).
NUCLEAR TECHNIQUES AND MINERAL RESOURCES.
Report on the Agency Symposium held in Buenos Aires, Argentina, 5-9 November 1968.
Conferences and Symposia.
Vol. 7, No. 2 (1969) p. 231-235.

12 Beswick, C. K., Yuan, H. C. (International Atomic Energy Agency, Vienna (Austria)).
UTILIZATION OF LARGE RADIATION SOURCES AND ACCELERATORS IN INDUSTRIAL PROCESSING.
Report on the Symposium held in Munich, Federal Republic of Germany, 18-22 August 1969.
Conferences and Symposia.
Vol. 7, No. 4 (1969) p. 265-270.

Bödy, Z.
see Csikai, J.: 20

13 Briggs, D. S. (International Atomic Energy Agency, Vienna (Austria)).
ADVANCED AND HIGH-TEMPERATURE GAS-COOLED REACTORS.
Report on the Agency Symposium held at Jülich, Federal Republic of Germany, 21-25 October 1968.
Conferences and Symposia.
Vol. 7, No. 1 (1969) p. 139-151.

14 Briggs, D. S. (International Atomic Energy Agency, Vienna (Austria). Div. of Nuclear Power and Reactors).
OPERATING EXPERIENCE WITH NUCLEAR POWER PLANTS IN MEMBER STATES.
Current Research and Development.
Vol. 7, No. 4 (1969) p. 167-214.

This report summarizes information available on operating experience with nuclear power plants in Member States of the International Atomic Energy Agency. As far as possible, information has been taken from official sources but other sources have been used to supplement the data. References are given where more details can be found. Sixteen tables contain information for each station on location, gross and net full power electrical output, net thermal efficiency, and dates of start of construction, initial criticality, initial full-power and commercial operation; annual and total gross electrical generation; annual plant capacity factor; and annual reactor availability. The stations are grouped according to the following reactor types: graphite-moderated, gas-cooled; pressurized water; boiling water; heavy-water-moderated; graphite-moderated, light-water-cooled; and fast. The text includes an introductory summary for each type of reactor, followed by an outline of experience with individual plants. Among the general conclusions are that nuclear power plants have accumulated about 500 reactor-years' operating experience; that their safety is exceptionally good; that their availability has, in general, been satisfactory with an overall tendency to improvement after the first one or two years of operation; and that most of the outages have been due to faults in the conventional parts of the plants.

15 Briggs, D. S., Khan, Munir A., Kruck, P. H., Ristic, M. (International Atomic Energy Agency, Vienna (Austria). Div. of Nuclear Power and Reactors).
SMALL AND MEDIUM POWER REACTORS: PRESENT STATUS AND PROSPECTS.
Current Research and Development.
Vol. 7, No. 3 (1969) p. 119-152.

A review is given of the present technological and economic status of land-based nuclear power plants in the small and medium-size range (taken as 50-500 MW(e)) and their possible future trends are considered. It appears that the current high capital cost of small and medium power reactors (SMPRs) constitutes the major problem in making them competitive with the principal contenders – oil-fired stations. The market potential for these plants, which is closely linked to their ability to compete with alternative plants, is also discussed. While there appears to be a significant market potential for small and medium power reactors in certain areas of industrialized countries, the majority of customers for such plants are expected to be the developing countries. At present some of the principal reactor suppliers are concentrating on large-sized nuclear units. If they were convinced that an adequate market for SMPRs existed, they would devote the necessary efforts to their further development and so improve their competitive status. The report outlines the program of the IAEA and the steps it is undertaking to obtain more detailed information on the availability and costs of SMPRs and their market potential so that both suppliers and customers may have sounder bases on which to form their judgements.

16 Bruninx, E. (European Organization for Nuclear Research, Geneva (Switzerland)).
RADIOISOTOPE SEPARATORS AND MASS SPECTROMETERS IN NUCLEAR AND RADIOCHEMISTRY.
Vol. 4, No. 1 (1966) p. 107-148.

The most common types of laboratory radioisotope separators and mass spectrometers are discussed. Emphasis is laid upon their performances, and their advantages and disadvantages. The use of these instruments in nuclear and radiochemistry, nuclear spectroscopy of short or long-lived nuclides, labelling and range studies is examined.

17 Brunson, G. S. (International Atomic Energy Agency, Vienna (Austria)), Oliveira, J. M. C. (Junta de Energia Nuclear, Sacavém (Portugal). Laboratório de Física e Engenharia Nucleares).
PROMPT-NEUTRON LIFETIME MEASUREMENTS WITH AN IMPROVISED TIME ANALYSER IN THE 'REACTOR PORTUGUÊS DE INVESTIGAÇÃO (RPI)'.
Current Research and Development.
Vol. 2, No. 4 (1964) p. 95-103.

The Rossi-α method makes use of the correlation of neutron detections to obtain the average period of prompt-neutron chains in a neutron multiplying system near critical. Pulses from a neutron detector of high sensitivity after amplification in conventional electronics are carried to a time analyser, which, starting with some neutron pulse, examines subsequent increments of time for delayed coincidences. After many cycles of analysis, we obtain a distribution of delayed coincidences, which, when corrected for random events, yields an exponential slope corresponding to $\Delta K_p/\tau_0$, where ΔK_p is the reactivity of the system relative to prompt critical and τ_0 is the prompt neutron lifetime of the system. The experiment is widely performed since the lifetime has practical as well as academic interest; the prompt-neutron lifetime is one of the factors entering into any comprehensive hazards analysis. Normally the time analysers used in this measurement are intricate and expensive. The present work is of interest because we have accomplished the measurement with minimal equipment: one conventional neutron detecting channel, an oscilloscope, an oscilloscope camera, and a motor-driven potentiometer. The sweep of the oscilloscope was triggered by neutron pulses; any pulses arriving during the sweep caused a momentary spot of light to appear at some x-coordinate representing the delay from the initiating pulse. These spots were recorded photographically and counted by hand. Analysis of data taken with a high sensitivity fission counter in the Reactor Português de Investigação yielded a prompt neutron lifetime of 48 ± 4 μs as compared with a calculated lifetime of 52.8 μs. Since this experiment may have pedagogical interest, we offer some criteria for feasibility. In general a good experiment requires: 1. A total spontaneous neutron source less than one fifth of a neutron/τ_0. 2. A counter sensitivity greater than 0.01 $\sqrt{\tau_0}$ counts/fission (for reactors fuelled with ^{235}U). For systems fuelled with plutonium or uranium-233, the counter sensitivity should be greater than 0.002 $\sqrt{\tau_0}$ counts/fission. If a system has a low source level, the sensitivity requirements are substantially reduced. Finally, the best overall signal-to-noise ratio is obtained 1$ below delayed critical; however, when the spontaneous source is small, it is desirable to make the measurement nearer delayed critical so that the data can be better extrapolated to delayed critical.

Buczkó, M.
see Csikai, J.: 20

Burris, L., Jr.
see Lawroski, S.: 59

18 Bush, S.H. (General Electric Co., Richland, Wash.).
SPECIAL MATERIALS FOR REACTOR CONSTRUCTION AND THEIR METHODS OF FABRICATION.
Vol. 1, No. 1 (1963) p. 43-92.

A survey has been made of the literature published since the Second United Nations International Conference on the Peaceful Uses of Atomic Energy dealing with the materials used in nuclear reactors and the methods of fabrication of these materials into reactor components. The reactor concepts examined were those for civilian power generation; coolants included water, deuterium oxide, sodium, organic liquids, or gases. The reactor components considered were the pressure vessel, pressure tubes, primary coolant piping, calandrias, grids, heat exchangers and steam generators, and other internal "hardware" (valves, pumps, gaskets, bolts, etc.). The structural materials used for these component applications were examined. Methods of component fabrication are reported when they are believed to represent major changes or advances. Particular emphasis was given to the joining of materials. Also, future trends in materials and methods of fabrication were analysed to anticipate limitations in the use of currently popular materials. Concrete, laminated and alloy-steel pressure vessels are discussed within the framework of future trends. Possible limitations of high-temperature alloys due to radiation effects are considered to the extent that they influence the design of reactor components.

Cameron, J.
see Beswick, C.K.: 11

Cameron, J.F.
see Zuber, A.: 105

19 Coleman, C.F. (Oak Ridge National Lab., Tenn.).
AMINE EXTRACTION IN REPROCESSING.
Vol. 2, No. 2 (1964) p. 3-54.

In the sixteen years since amine extraction was first reported, it has developed into one of the major categories of solvent extraction systems. Its industrial use, particularly in the hydrometallurgical processing of uranium and related metals, has both stimulated and benefitted from the commercial production of an increasing range of high molecular weight amines, especially secondary and tertiary amines. Amine extraction appears to promise special advantages in several aspects of nuclear fuel reprocessing by virtue of high extraction power, selectivity and reagent stability. This review presents recent developments and current status in amine extraction systems as pertinent to their potential use in nuclear fuel reprocessing, including both studies of the extraction systems per se and their adaptation to particular process uses. Proposed chemical flowsheets are cited for a number of processes in and auxiliary to fuel reprocessing. Literature references are arranged so as to facilitate access to previous reviews and bibliographies and to specialized studies of the amine systems.

20 Csikai, J., Buczkó, M., Bődy, Z., Demény, A. (Kossuth Univ., Debrecen (Hungary). Inst. of Experimental Physics).
NUCLEAR DATA FOR NEUTRON ACTIVATION ANALYSIS.
Vol. 7, No. 4 (1969) 93-128.

The aim of this work is to survey the nuclear data determining the applicability of neutron generators in activation analysis. A compilation of the activation cross-sections for (n, 2n), (n, p), (n, α) and (n, γ) reactions is given. Possible sources of discrepancies in the data are discussed. The accuracy of the half-lives and the status of knowledge about decay schemes of the isotopes produced in neutron reactions are considered. The neutron reactions giving a maximum yield and the interfering reactions are summarized.

21 Czvikovszky, T. (Plastics Research Inst., Budapest (Hungary)).
WOOD-PLASTIC COMBINATION BY MONOMER IMPREGNATION AND RADIATION POLYMERIZATION.
Vol. 6, No. 3 (1968) p. 3-100.

Wood impregnated with vinylmonomers, which are then polymerized in situ with high-energy radiation, is a very promising new structural material, a product of the radiation-induced graft-copolymerization.

On the basis of the literature (up to about June 1967), and of the author's experiments, a survey is given on the present status of wood-plastic combination research. After briefly reviewing the effect of radiation on wood, the author deals with the different aspects of radiation polymerization in wood: the main characteristics of polymerization, the inhibition, retardation, effect of temperature, dose-rate, water and solvents, the molecular weight of polymer formed in the wood, the ratio of grafting to homopolymerization, and the three-dimensional copolymerization in wood. The technological outlines of industrial possibilities are also considered; and the general conditions of impregnation and of irradiation demonstrated. The second part gives a survey of the processing and properties of different wood-plastic combinations. Special attention is paid to new trends: two-component monomer systems combined with wood, and oligomer-monomer systems combined with wood. Also discussed are the advantages and disadvantages of the competing method: i.e. polymerization by chemical methods (without radiation), based on the examples of those combinations already studied. The economic aspects are considered on the basis of the literature. Some possible applications of the new type of structural material and an estimation of market volume are also given. There is a brief review of the surface-coating of wood by radiation polymerization. The references include an additional list of reports that appeared after the review was completed.

22 Davydov, A.S. (Akademiya Nauk Ukrainskoi SSR, Kiev. Institut Teoreticheskoi Fiziki).
COLLECTIVE EXCITATIONS OF EVEN-EVEN ATOMIC NUCLEI.
Vol. 6, No. 2 (1968) p. 3-58.

The review deals with fundamental theoretical research on collective excited states of even-even atomic nuclei. The classification of excited states in spherical and non-spherical nuclei is investigated. Chief attention is focused on the phenomenological theory of quadrupole excited states, the different approximations in this theory being investigated. It is shown that in phenomenological theory the energies of excited states and the probabilities of electromagnetic transitions between them can be expressed by a certain number of parameters which characterize the shape of the nucleus in its ground state and its deformability. The theory of octupole excited states is briefly set out. The connection is noted between the phenomenological theory and the "microtheory" of collective excited states.

23 Dejonghe, P. (Centre d'Etude de l'Energie Nucléaire, Mol (Belgium)).
REVIEW OF RADIOACTIVE WASTE MANAGEMENT IN WESTERN EUROPE.
Current Research and Development.
Vol. 5, No. 4 (1967) p. 169-180.

Demény, A.
see Csikai, J.: 20

24 DiStefano, J.R., Hoffman, E.E. (Oak Ridge National Lab., Tenn.).
CORROSION MECHANISMS IN 'REFRACTORY METAL-ALKALI METAL' SYSTEMS.
Vol. 2, No. 1 (1964) p. 3-33.

Liquid metals make excellent high-temperature coolants because of their low vapour pressures and excellent heat-transfer coefficients. These properties recommend their use in nuclear power reactors where very high heat fluxes from the nuclear fuel are present. Liquid metals are also most attractive coolants and working fluids for space power systems which require compact design. The use of liquid metals, however, introduces solid-liquid metal interactions which are not primarily electro-chemical, as found in systems involving aqueous media. The corrosion of solid metals by these coolants occurs as the system attempts to attain chemical equilibrium. The mechanisms by which this can occur are (a) dissolution, which results from the solubility relationships between the solid and liquid metals, and (b) impurity reactions, resulting from the presence of interstitial impurities such as oxygen, nitrogen, and carbon, in the solid and liquid metals. The manner in which dissolving proceeds gives rise to many types of attack, ranging from simple solution to mass transfer of one or more constituents of an alloy. Some variables which influence the rate and type of dissolutive corrosion are: temperature, flow velocity, surface area to volume ratio, surface condition of solid metal, temperature gradient and number of materials in contact with the same liquid metal. The refractory metals tungsten, molybdenum, tantalum and niobium, as well as other high-melting body-centred cubic metals, have excellent resistance to dissolutive attack by the alkali liquid metals at high temperatures. However, there are numerous occasions when it is desirable to utilize the unique capabilities of several structural materials in the same system. A few experiments have been conducted which show that, when more than one type of solid metal or alloy is in contact with an alkali metal, the tendency for the system to achieve equilibrium results in a number of complex interactions involving interchange of metallic and nonmetallic constituents. These interactions generally are deleterious and therefore choice of materials may be limited. The most significant corrosion problem involving refractory metals appears to be the influence of the impurities, oxygen, nitrogen and carbon. Experiments have been conducted to study the effect of such impurities in both the refractory metals and alkali metals. As an example, data are presented which show that the presence of small quantities of oxygen in either tantalum or niobium results in the penetration of these metals by lithium over a wide range of temperatures. It has also been found that oxygen in sodium increases the corrosion rate when in contact with niobium and other refractory metals. In addition, a method of predicting the redistribution of impurities which are present in solution in either the solid or liquid metal is compared with experimental results. The corrosion of solid metals by liquid metals often occurs in complex multi-component systems. For this reason, further data on solubilities of single components, multi-component effects, temperature coefficients of solubilities, and kinetics of dissolution and precipitation of solid metals are needed. It is also suggested that more emphasis be placed on analytical techniques for determining the concentrations of oxygen, nitrogen and carbon in liquid metals in order that their effects upon the various corrosion processes might be better understood.

25 Dolničar, J. (International Atomic Energy Agency, Vienna (Austria)).
NUCLEAR FISSION.
Impressions from the Second Symposium on Physics and Chemistry of Fission held in Vienna, Austria, 28 July - 1 August 1969.
Conferences and Symposia.
Vol. 7, No. 4 (1969) p. 271-276.

26 Douglass, D. L. (General Electric Co., Pleasanton, Calif. Vallecitos Atomic Lab.).
THE PHYSICAL METALLURGY OF ZIRCONIUM.
Vol. 1, No. 4 (1963) p. 71-237.

A critical review and analysis of the physical metallurgy of zirconium has been made for the period 1953-1963 in order to bring the subject up to date since the publication of books by Lustman and Kerze and by Miller. Topics covered include: crystallography; physical properties; deformation and textures; recovery, recrystallization, and grain growth; theory of alloying; phase equilibria; phase transformations and heat treatment; mechanical properties; diffusion; and irradiation effects.

27 Dubinin, N. P., Tarasov, V. A. (Akademiya Nauk SSSR, Moscow. Institut Obshchei Genetiki).
PROBLEMS OF RADIATION MUTAGENESIS.
Vol. 6, No. 3 (1968) p. 101-212.

The work is concerned with some fundamental problems of radiation-induced mutagenesis. Initial lesions of the genetic cellular mechanism were recently shown to be reversible. The paper discusses in detail the varying probability of the fixation of premutational damage as mutation depending on intra-cellular conditions and some other modifying factors. Much attention is paid to the kinetics of mutagenesis induced by single, fractionated and prolonged irradiations. An especially important aspect of the problem is the study of types of chromosome aberrations successively varying throughout the cell cycle. Based on this, the authors discuss recent knowledge with respect to this issue, trying to develop it further by a hypothesis aimed at explaining the nature of this phenomenon and at foretelling the time point of chromosome aberration transition into chromatid aberration. Comments are made on the hypothesis of the limited number of the sites where chromosome exchange may occur.

28 Dwyer, O. E. (Brookhaven National Lab., Upton, N. Y.).
RECENT DEVELOPMENTS IN LIQUID-METAL HEAT TRANSFER.
Vol. 4, No. 1 (1966) p. 3-92.

This review summarizes developments in liquid-metal heat transfer which have occurred, for the most part, during the past five years. It presents comparisons between theoretical and empirical predictions and experimental results, with accompanying discussions. Also, areas where further research is needed are indicated. Since the subject cannot be completely covered in a single article, emphasis is given to those topics of most engineering interest. Moreover, with each topic the thoroughness of treatment varies according not only to reported progress but also to current interest. The principal topics covered include liquid-metal heat transfer for: (a) flow in pipes, (b) flow in annuli, (c) flow between parallel plates, (d) in-line flow through rod bundles, (e) 90° cross flow through rod bundles, (f) oblique flow through rod bundles, (g) pool boiling, (h) natural-convection boiling in a recirculating loop, (i) forced-convection boiling in a recirculating loop, and (j) critical heat flux in both pool and forced-convection boiling.

Ekberg, K.
see Westcott, C. H.: 101

29 Emelity, L. A. (International Atomic Energy Agency, Vienna (Austria)).
TREATMENT OF AIRBORNE RADIOACTIVE WASTES.
Report of the Agency Symposium held at UN Headquarters, New York, USA, 26-30 August 1968.
Conferences and Symposia.
Vol. 6, No. 4 (1968) p. 91-108.

Eramzhyan, R. A.
see Balashov, V. V.: 5

30 Eubanks, I. D. (Oklahoma State Univ., Stillwater. Dept. of Chemistry).
RADIATION AND CHEMICAL STABILITY OF AMINES.
Vol. 7, No. 3 (1969) p. 49-90.

The use of high-molecular-weight amines in solvent extraction has become widespread in recent years. The extraction behaviour of most inorganic ions has been determined for a variety of experimental conditions. Amines have been generally considered to possess exceptionally good chemical and radiolytic stability, and little concern has been given to amine degradation reactions in the course of developing amine-based solvent extraction processes. The available evidence, however, suggests that amines are frequently degraded by the process chemicals used. Amine reactions are initiated either photochemically or radiolytically. The reaction path usually involves initial reaction of a methylene hydrogen on the carbon atom α to the nitrogen. Reactions of amines with molecular oxygen, halocarbons, hydrocarbons, water, nitric acid, and nitrous acid are reviewed. The instability of amines toward nitric acid appears to be great enough to prevent their successful use in reprocessing flowsheets in which solvent is recycled except when protective reagents are added.

31 Evrard, C., Roels, J., Rémy, P., Tshitenge, G., Pollak, H. (Université Lovanium, Kinshasa (Democratic Republic of the Congo). Centre Trico).
DETECTION OF ALUMINIUM COLLECTORS IN CONGOLESE FLORA BY NEUTRON ACTIVATION.
Vol. 5, No. 3 (1967) p. 119-125.

Some Angiosperms collect aluminium in their tissues. This feature is a valuable help in the taxonomic study of certain groups. The ecology of these plants is also typical, as they are all found in acidic soils. The term "aluminium collector" is applied to a plant containing more than 1000 ppm of aluminium. The organ examined is usually the leaf. Chenery (1948) carried out an extensive survey of aluminium collectors amongst the world's flora and drew taxonomic and ecological conclusions using the "aluminon test", consisting of chemical analysis by colorimetry. The authors have devised a method using activation analysis. The leaves are crushed, dried and placed in a gelatine capsule. The capsule containing the leaf powder and another containing a known quantity of aluminium (standard) are activated simultaneously. The samples are irradiated in a TRIGA Mark 1 reactor, outside the reflector to avoid the production of aluminium due to fast-neutron capture by the silicon. Activation analysis is fast and more accurate than the chemical method; it is possible to achieve an accuracy of the order of 500 ppm, which is quite adequate for detecting and classifying collectors. A sample can be analysed in five minutes. A check on about 20 plants chosen from local flora confirmed Chenery's conclusions, as the main collectors were found in the genera Craterispermum, Psychotria (Rubiaceae) and Memecylon (Melastomaceae). In addition to this specific test, various leaves of C. laurinum from different trees growing in varying soils were analysed to establish individual differences.

32 Fainstein, F. E., Kiselev, A. E. (Tsentral'nyi Institut Gematologii i Perelivaniya Krovi, Moscow (USSR)), Kozinets, G. I. (International Atomic Energy Agency, Vienna (Austria)).
CURRENT PROBLEMS OF BONE MARROW TRANSPLANTATION.
Vol. 4, No. 4 (1966) p. 83-142.

This review deals with the current status of the comparatively new and, in many respects, still insufficiently studied problem of bone marrow transplantation. This is of great importance in the search for a rational system of combined treatment of the various processes resulting from the effects of ionizing radiations on the organism. The authors present experimental and clinical data confirming that the introduction of bone marrow auto- and homotransplantation into therapeutic practice has provided a wider scope for the use of radiotherapy and chemotherapy in the treatment of many serious pathological conditions. The review also summarizes data on other theoretical and practical approaches to the problem of bone marrow transplantation. These relate to the mechanism of action of myelotherapy, the peculiar features of the immunological reactions occurring in homotransplantation, possible ways of suppressing incipient immunological conflict, and problems of removing and conserving bone marrow. In their analysis of the materials available in the literature, the authors have also attempted to draw attention to some of the main lines that could be followed in subsequent work on the basic problems of bone marrow transplantation.

Feldman, I.I.
see Berzin, A.K.: 10

33 Frindel, E. (Institut Gustav Roussy, Villejuif (France). Departement des Radiations).
RADIATION EFFECTS ON CELLULAR KINETICS.
Vol. 4, No. 3 (1966) p. 3-37.

As a result of the advent of autoradiographic techniques it is now possible to study the cell cycle. Little is known about the biochemical process that initiates mitosis and DNA synthesis, and about the mechanism of mitotic delay induced by ionizing radiations. The radiosensitivity of cells in vitro and in vivo varies with the stage of the cell cycle at the time of radiation. The fluctuations in recuperation kinetics after fractionated doses of radiation are explained partly by cell recovery from sublethal damage and partly by cell movement through the cell cycle. The repair process is investigated indirectly by using different agents that are likely to inhibit this process. The effects of radiation on DNA synthesis are described in the light of recent interpretations which indicate indirect rather than direct effects on the biochemical process of DNA synthesis, and are explained in terms of cellular kinetics.

34 Frolov, Yu. G., Ochkin, A. V., Sergievskii, V. V. (Moskovskii Khimiko-Tekhnologicheskii Inst. (USSR)).
THEORETICAL ASPECTS OF AMINE EXTRACTION.
Vol. 7, No. 1 (1969) p. 71-138.

This review paper deals with questions concerning the interactions which take place in the organic phase during amine extraction. The authors consider the position of amines in the general classification of extraction agents and the principal parameters determining the relationship between the extraction properties of amines and their structure: the basicity of amines and the intramolecular bond in amine salts. The association of amine salts, their solvation by different solvents and the influence of these factors on extraction are discussed. Reference is made to the results of investigations carried out in allied chemical fields. Possible correlations between the extraction properties of amines and parameters dependent on their structure and on the nature of the diluents used are considered.

35 Genna, S., Jaeger, R. G., Nagl, J., Sanielevici, A. (International Atomic Energy Agency, Vienna (Austria)).
QUASI-ADIABATIC CALORIMETER FOR THE DIRECT DETERMINATION OF RADIATION DOSE IN rad. Current Research and Development.
Vol. 1, No. 4 (1963) p. 239-254.

A quasi-adiabatic calorimeter with an automatic temperature-control system and accessories for electrical calibration and determination of external radiation beam dose is described. The basic theoretical background of the method is discussed. Calibration diagrams and their evaluation in the dose range above 20 rad/min with an accuracy of within ± 1% are given. The instrument, which is constructed entirely from Tissue Equivalent Muscle (T.E.M.) material, can be easily moved for intercomparison and standardization purposes.

36 Gilli, P. V., Tchernilin, Yu.F. (International Atomic Energy Agency, Vienna (Austria)).
ELECTRICITY FROM MHD, 1968.

Report on the Agency Symposium held in Warsaw, Poland, 24-30 July 1968.
Conferences and Symposia.
Vol. 6, No. 4 (1968) p. 109-112.

37 Goldanskii, V. I. (Akademiya Nauk SSSR, Moscow. Institut Fizicheskoi Khimii).
THE MÖSSBAUER EFFECT AND ITS APPLICATIONS IN CHEMISTRY.
Vol. 1, No. 4 (1963) p. 3-70.

The relationship between nuclear properties and transformations and electron shell structure can be observed in a number of phenomena – isotope and isomeric optical shifts, chemical shifts in NMR and NQR spectra, and changes in the lifetime of isotopes undergoing electron capture or isomeric transition with conversion. A striking example of this type of relationship is provided by the way the shape of Mössbauer spectra varies as a function of the chemical state of atoms which emit and absorb γ-quanta. In this survey, the general characteristics of the Mössbauer effect, isomeric (chemical) shifts and quadrupole splitting of Mössbauer spectral lines are described. Characteristics of the Mössbauer effect which are important in conjunction with its application to problems of molecular structure – such as the prevalence of Mössbauer nuclei, the role of a light-atom environment, "short-range" and "long-range" effects and relaxation times – are also discussed. The most important chemical aspects of the first Mössbauer experiments in iron are considered: studies dealing with local magnetic fields in Fe^{2+} and Fe^{3+}, the contribution of s electrons to the valence bonds of iron atoms, compounds in which iron performs a double function, the chemical states of iron after beta-decay of cobalt, and a study of ferrocene and its derivatives. Similarly, the survey deals with the basic chemical aspects of the first Mössbauer experiments in tin. This includes the problem of covalent and ionic bonds in Sn^{2+} and Sn^{4+}, the role of co-ordination bonds, the role of electronegativity in atoms near tin, the structural differences between stannic tetrafluoride and other tetrahalides and inductive and mesomeric effects in Mössbauer spectra. The nature of line splitting is discussed, as is the possibility of studying the properties of monocrystals in polycrystalline samples. Mössbauer spectra of organo-tin compounds and their structural properties, as well as the Mössbauer effect in tin-bearing polymers are considered. In conclusion, a few questions of general interest are considered, including the prospects of using the Mössbauer effect in chemistry. The author discusses the influence of the nearest as well as the more remote intramolecular bonds; collective interaction in polymers (in conjunction with the kinetics of solid-phase polymerization and the role of phase transitions); the structure of complex compounds; the possibility of studying the kinetics of topochemical and liquid-phase reactions; radiation-damage studies, including the problems of "annealing" and "retention"; the possibility of making analytical measurements; and finally, the possibility of observing resonance scattering and absorption in connection with macromolecular recoil.

38 Goldanskii, V. I. (Akademiya Nauk SSSR, Moscow. Institut Fizicheskoi Khimii).
PHYSICAL CHEMISTRY OF THE POSITRON AND POSITRONIUM.
Vol. 6, No. 1 (1968) p. 3-148.

This survey is devoted to one of the most important branches of contemporary nuclear chemistry – the use of positron annihilation as a tool for investigating the physical and chemical properties of matter. The author describes the general properties of positrons, the pattern of positron slowing-down in matter, the formation of the hydrogen-like atom called positronium and its properties. Three types of positron annihilation are considered: annihilation in free collisions with electrons, in positronium atoms and in compounds formed by positrons with atoms and molecules. The physical and chemical information to be derived from each of these annihilation mechanisms is analysed. The review examines the basic experimental methods of observing positron annihilation which make it possible to distinguish the characteristics of the different mechanisms. Data on inhibition of positronium formation are surveyed, and the possibilities offered by their use as a source of information on the mechanisms of electron slowing, ionization and excitation of molecules are considered. Experiments on positronium quenching are described and lines of research are suggested in which quenching could be used to investigate the kinetics of the reactions of hydrogen-like atoms in gases and condensed materials. The main results of research on electron momentum distributions, using measurements of the angular correlation of annihilation gamma-rays, are also described.

Goldanskii, V. I.
see Hogg, B. G.: 46

39 Goryachev, B. I. (Moscow State Univ. (USSR). Inst. for Nuclear Physics).
CROSS-SECTIONS OF PHOTONUCLEAR REACTIONS.
Tabulated Experimental Data.
Vol. 2, No. 3 (1964) p. 71-148.

This paper provides a summary of experimental results relating to the thresholds, cross-sections and yields of photonuclear reactions. Work published in periodicals up to the middle of 1963 is included in the table, which is based on a breakdown of the experimental material by elements (from sodium to the trans-uranium elements), the papers relating to each element being arranged in alphabetical order. Except for a few "old" papers, the data contained in all published works were used, provided they could be adapted to the tabular arrangement employed.

40 Gross, B. (International Atomic Energy Agency, Vienna (Austria)).
RADIOACTIVE DATING.
Report on an International Symposium held at Athens, Greece, 19-23 November 1962.
Conferences and Symposia.
Vol. 1, No. 2 (1963) p. 167-171.

41 Hanna, G. C., Westcott, C. H., Lemmel, H. D., Leonard, B. R., Jr., Story, J. S., Attree, P. M.
(International Atomic Energy Agency, Vienna (Austria)).
REVISION OF VALUES FOR THE 2200 m/s NEUTRON CONSTANTS FOR FOUR FISSILE NUCLIDES.
Vol. 7, No. 4 (1969) p. 3-92.

This study brings up to date the earlier survey of Westcott et al. (1965) by including all the new information that has become available. The experimental measurements, new and old, have been carefully reviewed. The quality of the input data has been improved, firstly by more detailed consideration of the neutron spectra in which measurements were carried out, and secondly by a new study of the influence of fission neutron spectra and delayed gamma rays on $\bar{\nu}$ measurements. New g-factors, revised standard cross-sections, and new α-decay half-life data are used. The fitting procedure is improved by including the g-factors as fitted parameters and by a better treatment of correlated errors. The following values for 2200 m/s constants are recommended (cross-sections in barns, g-factors for 20.4_4°C):

	^{233}U	^{235}U	^{239}Pu	^{241}Pu
σ_a	577.6 ± 1.8	678.5 ± 1.9	1012.9 ± 4.1	1375.4 ± 8.6
σ_f	530.6 ± 1.9	580.2 ± 1.8	741.6 ± 3.1	1007.3 ± 7.2
σ_γ	47.0 ± 0.9	98.3 ± 1.1	271.3 ± 2.6	368.1 ± 7.8
α	0.0885 ± 0.0018	0.1694 ± 0.0021	0.3659 ± 0.0039	0.3654 ± 0.0090
η	2.2844 ± 0.0063	2.0719 ± 0.0060	2.1085 ± 0.0066	2.149 ± 0.014
$\bar{\nu}_t$	2.4866 ± 0.0069	2.4229 ± 0.0066	2.8799 ± 0.0090	2.934 ± 0.012
g_a	0.9965 ± 0.0013	0.9787 ± 0.0010	1.0752 ± 0.0030	1.0376 ± 0.0014
g_f	0.9950 ± 0.0021	0.9766 ± 0.0016	1.0548 ± 0.0030	1.0486 ± 0.0053
g_η	0.9985 ± 0.0017	0.9979 ± 0.0018	0.9810 ± 0.0027	1.0106 ± 0.0051
σ_s^{bound}	10.7 ± 1.8	17.6 ± 1.5	8.5 ± 2.0	12.0 ± 2.6

$\bar{\nu}_t$ (^{252}Cf) = 3.765 ± 0.012

Hanna, G. C.
see Westcott, C. H.: 101

42 Hanway, J. J. (International Atomic Energy Agency, Vienna (Austria)).
USE OF ISOTOPES AND RADIATION IN SOIL ORGANIC-MATTER STUDIES.

Report on the Agency Symposium held in Vienna, Austria, 15-19 July 1968.
Conferences and Symposia.
Vol. 6, No. 3 (1968) p. 223-225.

43 Hara, R. (International Atomic Energy Agency, Vienna (Austria)).
CHEMISTRY RESEARCH BASED ON RESEARCH REACTORS.
Vol. 1, No. 1 (1963) p. 93-140.

Many nations have built or are building research reactors and are facing the problem of the efficient utilization and the selection of suitable areas of research. Research reactors have been applied to various fields of science and technology, among which both chemistry and physics have received primary attention. Chemistry research with research reactors is particularly important for most centres, especially for newly developed ones, since most chemistry research is easy to start, does not require expensive auxiliary equipment or facilities and can be applied practically. Based on a systematic survey, this article provides a picture of major chemistry research which has been carried out with research reactors and the basic concept of the application of reactors to the field of chemistry. Although the primary emphasis is placed on chemistry research carried out with low and medium flux reactors, a brief description is given of the role of high flux reactors in chemistry research and of the future development of chemonuclear reactors. This article, because of its basic concept, could be used by scientists who are planning chemistry research programs.

44 Hausner, H. H. (Polytechnic Inst. of Brooklyn, N. Y.).
BERYLLIUM AS A MODERATOR AND REFLECTOR FOR NUCLEAR REACTORS.
Vol. 1, No. 2 (1963) p. 99-166.

Beryllium is considered to be basically an excellent material for moderators and reflectors in nuclear reactors, because of its nuclear properties and many of its other physical and mechanical properties. Although known for a long time, beryllium has been developed into an engineering material only during the last few years. This review covers the latest international information on beryllium both as a metal and as an oxide. It covers the occurrence of beryllium in nature, its extraction and fabrication in the metallic and oxidic form. The physical metallurgy is extensively discussed and special emphasis is given to the important problems of beryllium ductility. Based on the most recent research and development work, physical, mechanical, chemical and nuclear properties of beryllium and beryllium oxide are described in detail. The behaviour of these materials in neutron irradiation is briefly discussed. The application of beryllium or beryllium oxide as a matrix material for dispersion-type fuel elements is described. Examples are given for beryllium materials at present being used in nuclear reactors. Data on metallography are reported and a brief review is given of the health hazards in handling beryllium and how to overcome them. The bibliography at the end of this review contains 99 of the most recent references to the beryllium literature.

45 Hine, G. J. (International Atomic Energy Agency, Vienna (Austria)).
MEDICAL RADIOISOTOPE SCINTIGRAPHY.
Report on the International Symposium held in Salzburg, Austria, 6-15 August 1968.
Conferences and Symposia.
Vol. 6, No. 4 (1968) p. 81-89.

Hoffman, E. E.
see DiStefano, J. R.: 24

46 Hogg, B. G., Laidlaw, G. M. (Manitoba Univ., Winnipeg. Dept. of Physics), Goldanskii, V. I., Shantarovich, V. P. (Akademiya Nauk SSSR, Moscow. Institut Fizicheskoi Khimii).
TABLE OF POSITRON ANNIHILATION DATA.
Vol. 6, No. 1 (1968) p. 149-212.

A portion of this table was compiled and circulated privately by B. G. Hogg as part of the Positrons Programs International in 1965. The table has been updated to mid year 1967. The compilers of the table have a primary interest in chemical physics and hence there may be certain omissions of data in areas not directly concerned with this field, for example of data on the gamma-ray angular correlation measurements on metals and alloys. A further list of references is given at the end of the paper "Physical Chemistry of the Positron and Positronium" by V. I. Goldanskii, in this volume.

Hoste, J.
see Adams, F.: 2

Jaeger, R. G.
see Genna, S.: 35

Jakeš, D.
see Jakešová, L.: 47

47 Jakešová, L., Jakeš, D. (Československá Akademie Věd, Řež. Ústav Jaderného Výzkumu).
CARBIDES, NITRIDES AND SILICIDES OF URANIUM AS PROMISING NUCLEAR FUEL.
Vol. 1, No. 3 (1963) p. 3-46.

New forms of nuclear fuel — carbides, mononitride and silicides of uranium — are opening up new ways of developing high-temperature reactors. The review discusses the chemical, physical and mechanical properties of these compounds; techniques for obtaining and compacting UC, UC_2, UN and uranium silicides, and their basic cermets; ways in which they are used in reactors; and possible fuel-element canning materials. Resistance to radiation is evaluated on the basis of the studies carried out. Final judgement on the merits and drawbacks of these materials will have to await the result of further investigation. This is particularly the case with the nitrides and silicides.

48 Janossy, L. (Magyar Tudomanyos Akademia, Budapest).
THE SO-CALLED PARADOXES OF THE THEORY OF RELATIVITY. (A Lecture).
Special Item.
Vol. 5, No. 2 (1967) p. 159-171.

49 Jaworowski, Z. (Institute of Nuclear Research, Warsaw (Poland)).
RADIOACTIVE LEAD IN THE ENVIRONMENT AND IN THE HUMAN BODY.
Vol. 7, No. 1 (1969) p. 3-45.

A summary is given of the results of studies performed during the last decade on the behaviour, occurrence and sources of ^{210}Pb in naturally and artificially contaminated humans and environment. The data on the levels of ^{210}Pb in the atmosphere, rain, potable and surface water, and in human and animal food are discussed. The patterns of the distribution of radioactive and stable lead in the body and the data on intake, elimination and other metabolic parameters are reviewed. The problem of "supported" ^{210}Po born from its parent ^{210}Pb in the tissue is also discussed, as well as the radiation dose attributable to this source. Special attention is paid to studies on professional exposure to ^{210}Pb in uranium mines.

50 Jonke, A. A. (Argonne National Lab., Ill.).
REPROCESSING OF NUCLEAR REACTOR FUELS BY PROCESSES BASED ON VOLATILIZATION, FRACTIONAL DISTILLATION, AND SELECTIVE ADSORPTION.
Vol. 3, No. 1 (1965) p. 3-60.

Although the reprocessing of irradiated fuels has been accomplished successfully for many years by solvent extraction processes, other reprocessing methods which do not depend on organic solvents and aqueous media appear to have important economic advantages. One such reprocessing method depends upon conversion of fuel materials to volatile compounds, such as uranium hexafluoride and plutonium hexafluoride; fractional distillation and/or adsorption techniques are employed to accomplish the necessary high degree of separation of uranium and plutonium from fission products and other constituents of the spent fuel. Processes based on volatilization methods are under development for application to a variety of nuclear fuels of both the low-enrichment type and the high-enrichment type. Several head-end procedures for accomplishing the halogenation reactions necessary for the preparation of volatile compounds have been investigated in various pilot plants, some of which have been operated with fully irradiated fuel elements. Head-end procedures employing gaseous reagents and fluidized-bed reaction equipment have, in recent months, received major attention in United States and European laboratories. In the concept of the fluidized-bed fluoride volatility process under development, fuel elements or bundles are immersed in fluidized solid media, and reacted with gaseous reagents to remove the cladding and to convert uranium and plutonium to the volatile hexafluorides. The latter compounds are then decontaminated, separated, and converted to final products for recycle to nuclear reactors. The status of development is approaching a point at which a full-scale reprocessing plant could be designed in the near future for some types of fully-enriched uranium fuels which do not contain plutonium in recoverable amounts. For plutonium-containing fuels, a few years of additional development work may be required, although a combination of volatility and aqueous processing methods could be put into operation much sooner. Pilot plants for development and demonstration of the fluidized-bed process with irradiated fuel elements are under design or construction in the United States, France and Belgium.

Kantor, S. A.
see Berzin, A. K.: 10

51 Kazachkovskii, O. D. (Nauchno-Issledovatel'skii Institut Atomnykh Reaktorov, Melekess (USSR)),
Lytkin, V. B. (Gosudarstvennyi Komitet po Ispol'zovaniyu Atomnoi Energii SSSR, Obninsk. Fiziko-Energeticheskii Inst.).
FAST POWER REACTORS.
Vol. 3, No. 4 (1965) p. 47-87.

This paper deals with questions related to the development of nuclear power on a large scale, such as can be obtained only through the use of fast reactors. The basic physical characterstics of fast power reactors are considered: high breeding ratios, high power density in the core, high concentration of fissile material, use of a liquid-metal coolant. The various types of fuel that can be used and possible methods of its chemical reprocessing are reviewed. The economic characteristics of fast power reactors are considered together with possible means of further improving them.

52 Keepin, G. R. (International Atomic Energy Agency, Vienna (Austria)).
PULSED NEUTRON RESEARCH IN NEUTRON AND REACTOR PHYSICS.
Vol. 2, No. 2 (1964) p. 75-95.

The capabilities of the pulsed neutron technique for neutron and reactor physics research are reviewed. A wealth of recent experimental and theoretical results is examined with a view toward the future potential of the pulsed method as an incisive research tool.

Khan, Munir A.
see Briggs, D. S.: 15

Kiselev, A. E.
see Fainstein, F. E.: 32

Koeteles, G.
see Antoni, F.: 4

53 Kolychev, B. S., Sedov, V. M. (Gosudarstvennyi Komitet po Ispol'zovaniyu Atomnoi Energii SSSR, Moscow).
THE PRESENT STATE AND PROSPECTS OF DEVELOPMENT IN RADIOACTIVE WASTE MANAGEMENT IN THE USSR.
Current Research and Development.
Vol. 5, No. 4 (1967) p. 123-150.

54 Komarov, E. I. (International Atomic Energy Agency, Vienna (Austria)).
BIOLOGICAL EFFECTS OF NEUTRON IRRADIATIONS.
Report on an International Symposium held at the Brookhaven National Laboratory, Upton, N. Y., 7-11 October 1963.
Conferences and Symposia.
Vol. 2, No. 1 (1964) p. 65-77.

55 Konshin, V. A., Matusevich, E. S. (Gosudarstvennyi Komitet po Ispol'zovaniyu Atomnoi Energii SSSR, Obninsk. Fiziko-Energeticheskii Institut).
CHARACTERISTICS OF THE INTERACTION OF HIGH-ENERGY NUCLEONS WITH NUCLEI.
Vol. 6, No. 4 (1968) p. 3-79.

The authors review the characteristics of the basic processes of interaction between high-energy (hundreds of MeV) nucleons with nuclei, taking as their starting point the requirements of calculations for radiation shielding against high-energy protons. They consider and discuss theoretical and experimental data relating to the cross-sections for the inelastic interaction of nucleons with nuclei, and data on the number and type of cascade and evaporated particles and on their angular and energy distributions.

Kozinets, G. I.
see Antoni, F.: 4
see Fainstein, F. E.: 32

56 Kozinets, G. I. (International Atomic Energy Agency, Vienna (Austria)).
ISOTOPES IN HAEMATOLOGY AND BLOOD TRANSFUSION.
Notes on the XIth Congress of the International Society of Haematology and the XIth Congress of the International Society of Blood Transfusion, held in Sydney, Australia, 21-29 August 1966.
Conferences and Symposia.
Vol. 4, No. 4 (1966) p. 169-172.

57 Krause, H. (Gesellschaft für Kernforschung m. b. H., Karlsruhe (West Germany)).
DISPOSAL OF RADIOACTIVE WASTES INTO DEEP GEOLOGICAL FORMATIONS.
Vol. 7, No. 1 (1969) p. 47-70.

With the continuous development of nuclear technology, the need for the ultimate disposal of radioactive wastes into deep underground storage sites is increasingly important, because this procedure can be applied on a large scale and completely excludes from the biosphere the radionuclides contained in the waste. According to the quality and activity of the wastes and the local geological conditions different methods can be used. Low- and intermediate-level effluents can be introduced under pressure into deep underground porous or fissured formations to the extent that these are completely isolated by impermeable strata from the water horizons that play their part in the biocycle. This method has been applied for some years quite successfully in the United States of America and the Soviet Union. If cleavable rock formations, especially shales, are available, radioactive liquids can be introduced into these under high pressure after having been mixed with cement and other aggregates. In this process, cleavages and fissures are formed along which the mixture can spread and in which it finally hardens. The fixation of radionuclides by cement and aggregates and the necessary insulation of the container rock from water-carrying strata guarantee the safety of the method. Solid rock is particularly suitable for storing solid waste. Since cavities in the rock are difficult to seal artificially, a natural insulation of the rock from groundwater by watertight strata is desirable. Radioactive liquids can be stored in caverns in rock only under particularly favourable geological conditions. In practice, vaults formed in rocks are used for storing low-level solid radioactive waste in Czechoslovakia and Spain. Up till now, no liquids have been disposed of in this way. Saline rock is particularly well suited to the storage of radioactive wastes of all kinds and classes of activity. The impermeability of saline rock to liquids safeguards absolute impermeability to the biosphere. The relatively good thermal conductivity of the salt even permits the storage of solid heat-generating wastes. Since saline rock of considerable depth exists in many countries and since it is possible to produce huge cavities in salt without any artificial support, this rock is excellently suited to the ultimate storage of radioactive wastes. Solid low- and intermediate-level wastes can simply be stacked in chambers of mines. High-level heat-generating wastes are best introduced into individual boreholes in the bottom of the chambers for better heat removal and covered with salt. Solid, liquid, and gaseous radioactive wastes can also be stored in caverns formed by solution mining. Comprehensive laboratory and field tests have been carried out, especially in the United States of America and the Federal Republic of Germany, with respect to the ultimate storage of radioactive wastes in salt. In the Federal Republic the first low-level wastes have already been introduced into a disused salt mine.

Kruck, P. H.
see Briggs, D. S.: 15

58 Krupchitskii, P. A., Lobov, G. A. (Gosudarstvennyi Komitet po Ispol'zovaniyu Atomnoi Energii SSSR, Moscow. Institut Teoreticheskoi i Eksperimental'noi Fiziki).
ANGULAR T-NON-INVARIANT CORRELATIONS IN THE ELECTROMAGNETIC RADIATION OF NUCLEI.
Vol. 7, No. 3 (1969) p. 91-118.

The authors consider various phenomena accompanying photon emission and absorption by nuclei when the time (T) invariance of strong or electromagnetic hadron interactions is violated. These phenomena are: angular correlations of two cascade photons in the decay of polarized nuclei; angular correlations in the resonance scattering of photon by polarized nuclei (studied with the help of the Mössbauer effect). Simple analytical expressions are presented for the angular correlation coefficients in the case of electric and magnetic dipole and quadrupole transitions of a nucleus with arbitrary spin values. The authors discuss the effects of virtual photon exchange leading to angular T-non-invariant correlations even when time invariance of the strong and electromagnetic hadron interaction holds true. Experiments relating to the degree of violation of the T-invariance of strong or electromagnetic hadron interactions are described and discussed.

Laidlaw, G. M.
see Hogg, B. G.: 46

59 Lawroski, S., Burris, L., Jr. (Argonne National Lab., Ill.).
PROCESSING OF REACTOR FUEL MATERIALS BY PYROMETALLURGICAL METHODS.
Vol. 2, No. 3 (1964) p. 3-69.

Pyrometallurgical processes are under development in order to achieve rapid recycle of high-burn-up reactor fuels. Potential economic advantages of these processes lie in their ability to handle short-cooled fuels, which permits of minimum fuel inventories, and in the avoidance or simplification of chemical conversions. The processes utilize high temperature separations in which the fuel is either maintained in the metallic state or subjected to a minimum of chemical conversions. Liquid metals and salts are frequently used as solvents. In this report, the principles of pyrometallurgical processes are discussed and the history of pyrometallurgical process development is reviewed briefly. Emphasis is given to recent developments and especially to impending demonstrations of these processes for recovery of fuel materials discharged from Argonne National Laboratory's Second Experimental Breeder Reactor (EBR-II). Fuel from this reactor will be processed and re-fabricated into new fuel elements for return to the reactor in an adjacent processing plant, known as the EBR-II Fuel Cycle Facility.

Leipunskaya, D. I.
see Berzin, A. K.: 10

Lemmel, H. D.
see Hanna, G. C.: 41

Leonard, B. R., Jr.
see Hanna, G. C.: 41

Lobov, G. A.
see Krupchitskii, P.A.: 58

60 Lovas, I. (Copenhagen Univ. (Denmark). Institut for Teoretisk Fysik), Zámori, Z. (Institute for Nuclear Physics, Krakow (Poland)).
PILE NEUTRONS IN NUCLEAR PHYSICS.
Vol. 3, No. 1 (1965) p. 61-140.

The aim of this review is to outline the main fields of nuclear physics in which the pile neutrons play an important role. The problems and methods of slow neutron spectroscopy are discussed including a short survey of resonance parameter properties. The general features of gamma spectra arising from neutron capture are given. A short comparison is made of the most frequently applied experimental techniques of gamma spectroscopy in the neutron-gamma reaction studies. Different methods for level spin assignment are discussed. Finally some fundamental problems connected with the properties of nuclear ineractions are reviewed.

Lupei, V.
see Ursu, I.: 98

Lytkin, V. B.
see Kazachkovskii, O. D.: 51

61 Malášek, E. (International Atomic Energy Agency, Vienna (Austria). Div. of Health, Safety and Waste Disposal).
TREATMENT OF RADIOACTIVE WASTES IN BULGARIA, CZECHOSLOVAKIA, THE GERMAN DEMOCRATIC REPUBLIC, HUNGARY, POLAND AND ROMANIA.
Current Research and Development.
Vol. 5, No. 4 (1967) p. 151-167.

62 Malm, J. G., Appelman, E. H. (Argonne National Lab., Ill. Chemistry Div.).
THE CHEMICAL COMPOUNDS OF XENON AND OTHER NOBLE GASES.
Vol. 7, No. 3 (1969) p. 3-48.

The experimental work carried out on the chemical compounds of the noble gases from 1962 through mid 1969 is reviewed systematically and critically. Such compounds as Vander Waals dimers, ion-molecules, and excited species observed in electrical discharges are excluded. The theoretical studies of the bonding in noble gas compounds are not comprehensively reviewed.

63 Marhol, M. (Československá Akademie Věd, Řež. Ústav Jaderného Výzkumu).
NEW DEVELOPMENTS IN ION-EXCHANGE MATERIALS, WITH SPECIAL EMPHASIS ON ION EXCHANGERS CONTAINING PHOSPHORUS, ARSENIC OR ANTIMONY IN THE FUNCTIONAL GROUP.
Vol. 4, No. 3 (1966) p. 63-156.

The steadily extending application of ion exchangers in both laboratories and plants stimulates their further development. One of the main development trends at present is toward improvement of the physical and chemical stability of ion exchangers and an increase in their selectivity. This review presents recent developments and the present status in the sphere of synthesis, properties and utilization of some groups of ion exchangers. In particular, the review treats ion exchangers that are potentially important for applications in nuclear technology, dealing, in addition, with some general problems of their development. The complete results from works published during the last five years are included, while the section on phosphorus- and arsenic-based organic ion exchangers presents results from the past fifteen years.

64 Maslennikov, M. V. (Akademiya Nauk SSSR, Moscow. Institut Prikladnoi Matematiki).
MILNE'S PROBLEM WITH ANISOTROPIC SCATTERING AND RELATED PROBLEMS.
Vol. 5, No. 2 (1967) p. 59-158.

The review gives the main results of the mathematical theory of the passage of monochromatic radiation through finite or semi-infinite plane-parallel layers of material. The single scattering of the radiation by the material is assumed to be anisotropic. Work on similar problems involving isotropic scattering is not dealt with. The main subjects discussed are the qualitative investigation of Milne's problem with a fairly general law of single scattering (solubility of the problem, properties of its solutions, asymptotic formulae, etc.) and some analytical methods of solving it. Among the questions related to Milne's problem, the review discusses the inverse problem of the asymptotic radiation transport theory, the asymptotic properties of solutions to problems dealing with the passage of radiation through finite plane layers of great optical thickness, the theory of the characteristic equation and some numerical methods of solving problems of transport theory with anisotropic scattering.

Matusevich, E. S.
see Konshin, V. A.: 55

65 Meyer, R. A., Rickard, C. L. (General Dynamics Corp., San Diego, Calif. General Atomic Div.).
THE IMPACT OF GRAPHITE FUEL DEVELOPMENT ON HIGH-TEMPERATURE STEAM GENERATION.
Current Research and Development.
Vol. 1, No. 3 (1963) p. 119-139.

The recent development in high-temperature graphite fuels gives promise of allowing fuel surface temperatures of approximately 1800°F, permitting the transfer of heat to make steam of 1000 to 1100°F in range, which in turn makes possible net plant efficiencies of over 40%. The thermodynamic and economic incentive for the development of this new high-temperature fuel, the potential it holds for the generation of high-temperature steam, and the associated development and testing work are discussed in this paper. The HTGR fuel element is of the solid semihomogeneous type in which graphite serves as the moderator, cladding fuel matrix and structure. The uranium and thorium within the fuel compacts are in the form of carbides, uniformly dispersed as particles in a graphite matrix. The (Th, U)C_2 particles are 150 to 400 μm in diameter. Each particle is pyrolytically coated with 50- to 60-μm-thick dense carbon. The fuel element development and testing program consisted in developing new processes for making new materials as well as evaluating existing materials for the various parts of the fuel element. Both out-of-pile and in-pile tests, in which the environment was selected to duplicate the conditions of the reactor, were extensively employed. The performance of the carbon coatings of the fuel particles was also evaluated in some of these irradiation tests. More than 40 different compacts were irradiated and metallographically examined after irradiations ranging from 15 000- to 60 000-MWd/t exposure in the temperature range from 1000 to 2100°C; the fuel particles and coatings remained intact. A program for the development of this new fuel was initiated in 1958 as part of the development program for the 40-MW(e) High-Temperature Gas-cooled Reactor (HTGR) for the Peach Bottom, Pennsylvania nuclear power station. This development work was successfully completed. Further development and application of the new fuel have been the subject of a research and development program being carried on jointly by General Atomic and Empire State Atomic Development Associates, Inc. (ESADA), with the objective of a 300- to 500-MW(e) HTGR plant for New York State.

66 Mikheev, N. B., Spitsyn, V. I. (Moscow State Univ. (USSR)).
APPLICATION OF CO-CRYSTALLIZATION AND ADSORPTION IN THE SOLUTION OF CURRENT PROBLEMS OF RADIOCHEMISTRY.
Vol. 3, No. 4 (1965) p. 3-46.

The development of contemporary radiochemistry and atomic industry raises a number of practical, as well as purely scientific problems. One of the most important of these is the problem of improving methods of separation of radioactive elements and isotopes, often present in quantities that cannot be weighed. Where physical methods, such as electromagnetic or diffusion, do not apply, the methods used for the solution of this problem are based essentially on the distribution of the components to be separated between phases. The distribution of the elements between the solid and liquid phases offers the basis for the processes of their separation by co-crystallization and adsorption. The distribution of the elements between two liquid phases offers the basis for the extraction method, while the varying distribution of the elements between the fluid and vaporous phases makes possible their separation by the distillation method. Co-crystallization and adsorption are historically the first methods applied in radiochemistry. At present these methods are still widely used in the reprocessing of nuclear fuel, for the deactivation of radioactive solutions and in the separation of radioisotopes as well as in various radiochemical investigations. It is obvious that the effectiveness of the separation of elements by the various methods, including those of co-crystallization and adsorption, depends on the chemical state of the elements to be separated as well as on the physico-chemical conditions governing the application of the process. A change in the parameters may influence the effectiveness of the separation of the elements. Recently the study of adsorption processes on crystal precipitates has undergone considerable development, and this method has found an important application in chromatography. Since the use of physico-chemical methods for separating radioactive substances necessarily involves dealing with highly active materials, the influence of radioactivity on processes that take place in heterogeneous systems has also been studied in recent years. It has been found that in many cases radioactivity affects the state of the system, exerting in this manner an influence on the processes of separation of the elements.

67 Morgan, W. C. (International Atomic Energy Agency, Vienna (Austria)).
RADIATION DAMAGE IN REACTOR MATERIALS.
Report on the Agency Symposium held in Vienna, Austria, 2-6 June 1969.
Conferences and Symposia.
Vol. 7, No. 3 (1969) p. 189-195.

68 Moskalev, Yu. I., Streltsova, V. N. (Akademiya Nauk SSSR, Moscow. Institut Biofiziki).
THE CARCINOGENIC EFFECTS OF IONIZING RADIATION. A Review of Current Problems.
Vol. 2, No. 3 (1964) p. 149-194.

A great deal of original work and a large number of review articles have been devoted to questions of the tumour-producing effect of radiation. A special feature of the present review is that it analyses the distinctive characteristics of the carcinogenic effect of external and internal sources of ionizing radiation depending on the radiation conditions and the organs or tissues involved, the role of the time factor, the mechanisms by which tumours occur and the dose-effect and threshold problems. A number of new theses are advanced, principally with regard to the dose-effect and threshold problems. The authors do not dwell on the history of the question or on particular aspects of it, but refer the reader to the specialized literature comprised in an extensive list of references at the end of the review. Data are given on the comparative effect of various isotopes.

69 Mukherjee, R. (International Atomic Energy Agency, Vienna (Austria)).
RADIATION INDUCED CANCER.
Review of the Agency Symposium held in Athens, Greece, 28 April - 2 May 1969.
Conferences and Symposia.
Vol. 7, No. 3 (1969) p. 181-188.

Nagl, J.
see Genna, S.: 35

70 Neudachin, V. G., Smirnov, Yu. F. (Moscow State Univ. (USSR). Inst. for Nuclear Physics).
NUCLEON CLUSTERS IN LIGHT NUCLEI.
Vol. 3, No. 3 (1965) p. 157-272.

Various forms of α-clustering of nucleons in light nuclei are considered. The role of the Majorana forces and characteristic features of the corresponding quantum numbers – the Young orbital diagrams $[\lambda]$ – are discussed. The relation between the shell model and the nucleon clustering model (NCM) is analysed. Experimental data on the $E\lambda$ transition probabilities and the relevant form factors for inelastic electron scattering are used to describe methods of determining the NCM parameters. A wide range of nuclear reactions is examined, giving one a deeper understanding of nucleon clustering, i.e. the resonance reactions involving nucleon clustering; the direct nuclear reactions of substitution of nucleon clusters, and the connection between the cross-section of the process and the Young diagram for the initial nucleus; the dipole photo-absorption, extensive splitting of the giant resonance in light nuclei, and "star" decay into nucleon clusters with highly excited states (the selection rules for Young diagrams in nuclear reactions are discussed); the reactions of quasi-elastic knock-out of nucleon clusters at high energies, and data provided by the effective numbers of nucleon clusters as well as the momentum distributions (the selection rules based on the SU_3 quantum numbers were found to be very useful); the γ-ray and π-meson absorption by α-clusters in nuclei (quasi-α-particle mechanism). The presentation of the physics problems is intended for both theoreticians and experimental physicists.

Nistor, S. V.
see Ursu, I.: 98

71 Nossal, G. J. V. (Walter and Eliza Hall Inst. of Medical Research, Melbourne (Australia)).
EFFECTS OF RADIATION ON ANTIBODY FORMATION. Current Views.
Vol. 5, No. 1 (1967) p. 3-41.

In this review, recent studies on the effects of radiation on the immune response are summarized, and an analysis is made of the different ways in which the irradiated animal has been used as a tool in immunological investigations. The effect of radiation on antigen-capturing mechanisms is examined, with special reference to the behaviour of antigen-retaining cells in the lymphoid follicles. The conclusion is reached that whole-body irradiation has previously unsuspected effects in reducing antigen capture in these areas of the lymphoid tissue, and that this effect may be due to a lowering of opsonin levels. Some experiments are cited on the effects of radiation on macrophage-lymphoid interactions but the conclusion is reached that such effects are not yet fully established. The genesis of immunocompetent cells is analysed in depth, and the respective roles of the bone marrow, the thymus and the recirculating pool of antigen-reactive cells in peripheral lymphoid tissue are dissected. Many examples are given which show how important radiation studies have been in clarifying our concepts on these major compartments in the immune system. Brief reference is made to the importance of the timing of irradiation in assessing damage to antibody production, and to studies on the restoration of radiation damage. A fuller analysis is made of the cellular kinetics of antibody formation, with special reference to the histological nature of antibody-forming cells and to feed-back and other controlling mechanisms. The effects of radiation on the state of immune tolerance are examined, with special reference to the new concept of two zones of antigen dosage capable of inducing tolerance, and to the finding that X-irradiation can, under some circumstances, help the induction of tolerance and under other circumstances actually accelerate the break-down of tolerance. Finally, the impact of these studies on current theories of antibody formation is summarized, and the conclusion is reached that present evidence favours selective rather than instructive theories of antibody formation.

72 Nosworthy, J. M. (Guy's Hospital Medical School, London (England). Physics Dept.), Swallow, A. J. (Christie Hospital and Holt Radium Inst., Manchester (England). Paterson Labs.).
SOME TRENDS IN RADIATION CHEMISTRY.
Vol. 2, No. 1 (1964) p. 35-63.

Fundamental radiation chemistry has expanded greatly in recent years. Many of the advances have derived from new experimental techniques, although the basic concepts of the subject had already been put forward as a result of relatively simple experiments by the nineteen-thirties. The problems in general radiation chemistry include accounting for the radiosensitivity of pure compounds and mixtures, understanding the role of intermediates, and explaining the manner in which energy is distributed between the components of an irradiated system. In the radiolysis of aqueous solutions, results can be interpreted in terms of the initial formation of free radicals and the recently discovered solvated electrons. Chemical systems are convenient for radiation dosimetry. Use of the Fricke Dosimeter is now well established, although it is still capable of further development. A need still exists for other chemical dosimeters. Some of the most remarkable advances in radiation chemistry have been in the polymer field. The study of the nature and reactions of the free radicals in irradiated polymethyl methacrylate by means of the electron spin resonance technique is a typical investigation into an important aspect of the mechanism of the action of radiation on a polymer.

Ochkin, A. V.
see Frolov, Yu. G.: 34

73 Okrent, D. (Argonne National Lab., Ill.).
DESIGN AND SAFETY IN LARGE FAST POWER REACTORS.
Vol. 7, No. 2 (1969) p. 135-223.

This review article places particular emphasis on the design measures taken with regard to safety for sodium-cooled fast reactors. Following a brief examination of safety issues and phenomena, primarily those associated with integrity of the core, some of the safety-related design features of fast reactors currently in operation or under construction are summarized. The approach to fast reactor safety adopted by various United States design groups in 1963-64 for conceptual studies of large fast reactors is compared with the reference designs presented by the same and other groups at the International Conference on Sodium Technology and Large Fast Reactor Design held at Argonne in November 1968. It is seen that opinions concerning the appropriate design approach to fast reactor safety are in a state of flux, varying from country to country, from designer to designer, and, with time, within a design group. The review concludes by posing some safety-related design and regulatory questions.

Oliveira, J. M. C.
see Brunson, G. S.: 17

74 Parker, F. L. (Vanderbilt Univ., Nashville, Tenn.).
RECENT DEVELOPMENTS IN AND FUTURE PLANS FOR RADIOACTIVE WASTE MANAGEMENT IN THE UNITED STATES OF AMERICA.
Current Research and Development.
Vol. 5, No. 4 (1967) p. 93-121.

Pattenden, N. J.
see Westcott, C. H.: 101

Pollak, H.
see Evrard, C.: 31

75 Proksch, E. (Österreichische Studiengesellschaft für Atomenergie, Seibersdorf).
PURIFICATION OF REACTOR MODERATOR-COOLANTS.
Vol. 1, No. 1 (1963) p. 5-42.

This review covers the problems related to the purification of light and heavy water and the organic liquids used as moderator-coolants for nuclear reactors. The different sources of impurities are described. Corrosion is the main source in water systems, radiolytic tar formation in organic systems. Specified and actually observed values for the concentration of different impurities are thoroughly discussed. The methods and the equipment used in purification are described. The main units to be considered are ion exchangers, filters, degasifiers, and distillation columns. Design, construction, operation and trends of development are discussed. The whole problem of purification can be solved at present by well-developed methods and with considerable success. However, most of them are capable of further improvement.

76 Pushkov, A. A. (International Atomic Energy Agency, Vienna (Austria)).
AQUEOUS REPROCESSING CHEMISTRY FOR IRRADIATED FUELS.
Report on an International Symposium held in Brussels, Belgium, 23-26 April 1963.
Conferences and Symposia.
Vol. 1, No. 3 (1963) p. 141-147.

77 Radnót, M. (University Medical School, Budapest (Hungary). Dept. of Ophthalmology No. 1).
EFFECTS OF IRRADIATION ON THE EYE LENS.
Vol. 7, No. 4 (1969) p. 129-165.

The author reviews the important publications on the effect of different ionizing radiations on the eye lens in humans and experimental animals. Recent data on the cell biology and biochemistry of the eye lens are also considered in order to give a better understanding of lesions in the lens and of the pathomechanism of cataract formation. The hypotheses proposed so far to explain the potential pathomechanisms are discussed, and attention is focused on those problems the solving of which would contribute to a clearer understanding of the biological effects of ionizing radiations. The review contains 339 references, most of which are of recent date.

Ravoire, J.
see Roth, E.: 78

Rémy, D.
see Evrard, C.: 31

Révész, L.
see Agranenko, V.: 3

Rickard, C. L.
see Meyer, R. A.: 65

Ristic, M.
see Briggs, D. S.: 15

Roels, J.
see Evrard, C.: 31

78 Roth, E., Ravoire, J. (Commissariat à l'Energie Atomique, Saclay (France). Service des Isotopes Stables).
METHODS OF HYDROGEN-DEUTERIUM ANALYSIS USED AT SACLAY.
Vol. 2, No. 2 (1964) p. 55-74. (In French)

Isotope chemistry and the study of isotope distribution in nature involve the use of various isotope analysis methods. In this article the methods developed at Saclay in the Department of Stable Isotopes for the study of hydrogen-deuterium systems are presented. They consist of mass spectroscopy, infra-red spectroscopy, density dosimetry, thermal conductivity and gas chromatography. These methods permit the satisfactory solution of deuterium-analysis problems in hydrogen and water.

79 Rozen, A. M. (Akademiya Nauk SSSR, Moscow. Sovet po Kibernetiki).
EXTRACTION PROCESSES AND THEIR MATHEMATICAL DESCRIPTION.
Vol. 6, No. 2 (1968) p. 59-135.

The present article deals with the quantitative laws governing extraction processes – the theory of extraction equilibria, calculations of the distribution and purification of substances in multi-stage (primarily radiochemical) extraction cascades, hydrodynamics and mass transfer in extractors, and the problem of scaling up extraction apparatus by means of models. It is based on work done by the author and his collaborators, and on published data. A particular feature of the article is its element-by-element approach to the problems concerning the extraction chemistry and the processes and apparatus of extraction technology. The basic steps of a complex extraction process are considered, and then the process as a whole. With this approach it is possible to elucidate the mechanism of such processes, discover the quantitative laws to which they are subject, and give a reasoned mathematical description of them.

80 Rubinstein, G. (International Atomic Energy Agency, Vienna (Austria)).
BRITTLE FRACTURE AND SAFETY PROBLEMS OF REACTOR PRESSURE VESSELS.
Report on an International Colloquium held in Brussels, Belgium, 11-13 January 1966, and organized by the European Atomic Energy Community (EURATOM).
Conferences and Symposia.
Vol. 4, No. 2 (1966) p. 181-188.

81 Rubinstein, G. (International Atomic Energy Agency, Vienna (Austria)).
INTERNATIONAL CONFERENCE ON THE CHEMISTRY OF THE SOLVENT EXTRACTION OF METALS.
Atomic Energy Research Establishment, Harwell, 27-29 September 1965, and Windscale Works, 30 September 1965.
Conferences and Symposia.
Vol. 4, No. 1 (1966) p. 149-158.

82 Růžička, J., Starý, J. (České Vysoké Učeni Technické, Prague (Czechoslovakia). Fakulta Technické a Jaderné Fyziky).
SUBSTOICHIOMETRY IN RADIOCHEMICAL ANALYSIS.
Vol. 2, No. 4 (1964) p. 3-58.

Substoichiometric separation is more selective than other radiochemical separation procedures, for it is based on the use of strictly controlled amounts of reagent (chelating, extracting, precipitating) in quantities less than those which stoichiometrically correspond to the amount of the element to be separated. Moreover, the substoichiometric principle avoids the necessity of determining the chemical yield. In the present paper is given the theory from which the best conditions can be calculated for attaining maximum selectivity and reproducibility of determination. The use of substoichiometry in activation analysis, isotope dilution and in the radiochemical analysis of mixtures of radioisotopes, such as radioactive preparations and fission products, is explained. Optimum conditions for determination of traces of 24 metallic elements are given. Advantages, disadvantages and trends in substoichiometry are discussed.

Sanatani, S.
see Westcott, C. H.: 101

83 Sani, L. (Ente Nazionale per l'Energia Elettrica, Rome (Italy). Direzione Costruzioni Centrali Termiche e Nucleari).
ANALYSIS OF DESIGN CRITERIA FOR BOILING WATER REACTORS.
Vol. 1, No. 3 (1963) p. 47-118.

This paper illustrates the design criteria for BWR nuclear power plants. The preliminary study of the plant thermodynamics is followed by an analysis of the parameters affecting the thermal design of the core. Particular attention is paid to the core thermal-hydraulic design, in view of the attainment of fairly high power density values without compromising the core safety and/or the system stability. The core nuclear design may finally be undertaken, with the aim of achieving two major objectives: economic optimization and nuclear safety.

Sanielevici, A.
see Genna, S.: 35

Sedov, V. M.
see Kolychev, B. S.: 53

84 Semenov, B. A. (International Atomic Energy Agency, Vienna (Austria)).
PHYSICS AND MATERIAL PROBLEMS OF REACTOR CONTROL RODS.
Report on an International Symposium held in Vienna, Austria, 11-15 November 1963.
Conferences and Symposia.
Vol. 2, No. 2 (1964) p. 97-107.

85 Semenov, B. A. (International Atomic Energy Agency, Vienna (Austria)).
REPORT ON FAST REACTOR TECHNOLOGY MEETING HELD IN DETROIT, 1965.
Conferences and Symposia.
Vol. 3, No. 4 (1965) p. 89-102.

Sergievskii, V. V.
see Frolov, Yu. G.: 34

Shantarovich, V. P.
see Hogg, B. G.: 46

86 Shevchenko, V. G. (International Atomic Energy Agency, Vienna (Austria)).
DIRECT INTERACTIONS AND NUCLEAR REACTION MECHANISM.
Report on an International Conference held at Padua, Italy, 3-8 September 1962.
Conferences and Symposia.
Vol. 1, No. 1 (1963) p. 141-148.

87 Shevchenko, V. G., Yudin, N. P. (Moscow State Univ., Moscow (USSR). Inst. for Nuclear Physics).
THE NATURE OF THE GIANT RESONANCE IN PHOTONUCLEAR REACTIONS.
Vol. 3, No. 3 (1965) p. 3-156.

The review is concerned with the main theoretical and experimental results so far obtained in studies of the nature of the giant resonance (dipole and quadrupole collective states). An account is given of the problems associated with the sum rules for dipole transitions as well as of the different model presentations that have proved successful in explaining the basic features of photoeffect.

Shimelevich, Yu. S.
see Berzin, A. K.: 10

88 Sinegribova, O. A., Yagodin, G. A. (Moskovskii Khimiko-Tekhnologicheskii Inst. (USSR)).
ZIRCONIUM AND HAFNIUM SEPARATION BY LIQUID-LIQUID EXTRACTION.
Vol. 4, No. 1 (1966) p. 93-106.

Extraction techniques are widely used for the separation of zirconium and hafnium and also for studying their chemical characteristics. Zirconium and hafnium pass into the organic phase and together with the extractants form salts or solvate complexes, depending on the composition of the aqueous solution and the extractant used. The paper discusses the chemistry of zirconium and hafnium extraction as performed with acid extractants, amines and organophosphorous ethers. Special attention is paid to the extraction of the two elements in the form of thiocyanate complexes.

Smirnov, Yu. F.
see Neudachin, V. G.: 70

89 Solovev, V. G. (Joint Inst. for Nuclear Research, Dubna (USSR)).
NON-ROTATIONAL COLLECTIVE STATES OF DEFORMED EVEN-EVEN NUCLEI.
Vol. 3, No. 2 (1965) p. 117-193.

This review article describes the non-rotational collective states in deformed even-even nuclei. The author states the fundamental propositions of the superfluid nuclear model and sets forth in detail the method of approximate secondary quantization. The secular equations for the energies of quadrupole and octupole states are derived, the special features of these equations studied and the wave functions of the collective states found. The author also derives expressions for the reduced probabilities of alpha, beta and gamma transitions to collective states. The experimental data on the energies of quadrupole and octupole excited states are systematized, and experimental data presented on the reduced probabilities of electromagnetic transitions from collective states and on alpha and beta decay to collective states. The author cites energy calculations for the two initial quadrupole and octupole states and for a number of electromagnetic and beta transition probabilities. He goes on to investigate the structure of collective states and to determine the relationship between quasi-particle and collective states. Theory and experiment are compared and shown to be in good agreement. The author comes to the conclusion that the superfluid nuclear model correctly describes that part of the residual interactions between nucleons which is of most importance in atomic nuclei at relatively low excitation energies.

90 Spitsyn, V. I. (Moscow State Univ. (USSR)).
THE CENTENARY OF D. I. MENDELEEV'S PERIODIC LAW. (A Lecture).
Special Item.
Vol. 7, No. 3 (1969) p. 153-180.

Spitsyn, V. I.
see Mikheev, N. B.: 66

91 Spurný, Z. (Československá Akademie Věd, Řež. Ústav Jaderného Výzkumu).
THERMOLUMINESCENT DOSIMETRY.
Vol. 3, No. 2 (1965) p. 61-115.

The review gives an analysis of literature on thermoluminescent dosimetry up to the Spring of 1965. The historical background and the necessary theory are given. Then the principles of the method are explained and the attempts to realize a personnel dosimeter are briefly reviewed. Types of phosphors, dose and dose-rate responses, precision and linearity obtainable, time stability of dosimeter response, temperature influence and stability, energy dependence and sensitivity to different kinds of radiation (including neutrons) are analysed. Next, certain other applications of radiothermoluminescence phenomenon are mentioned and a comparison of the main solid-state detectors is provided. Finally the possible trends of development and utilization of thermoluminescent dosimeters are described. A very full set of references and additional bibliography complete the review and provide a total of 275 references in the field.

Stary, J.
see Ružička, J.: 82

92 Steele, L. E. (Naval Research Lab., Washington, D. C.).
NEUTRON IRRADIATION EMBRITTLEMENT OF REACTOR PRESSURE-VESSEL STEELS.
Vol. 7, No. 2 (1969) p. 3-133.

The growing application of nuclear power has introduced the problem of materials changed by exposure to high-energy nuclear radiation. The steels which make up the primary containment vessels of nuclear reactors may undergo progressive embrittlement with neutron bombardment. Embrittlement is relative and may be small or large; it is important in either case because of the major function served by the vessel and the economic implications of overly conservative design and operating practice as a result of uncertainties. This report reviews the available literature results on the subject so as to highlight their engineering importance. Emphasis is placed upon the role of neutron radiation towards enhancement of brittle fracture of conventional and potential pressure-vessel steels. For perspective, the theoretical considerations involved, the current and projected growth of power reactors which utilize steel containment vessels and the practical aspects of defining the damaging potential of the nuclear environment are reviewed in the first three sections as background to the steel embrittlement data. The embrittlement data are reviewed to demonstrate the specific effects of several environmental and materials factors with emphasis upon those appropriate to light-water reactor service. The implications of large variations in embrittlement are highlighted to indicate the potential for minimizing steel embrittlement. Data for experimental studies and from reactor-vessel surveillance programs are correlated with emphasis upon understanding the role of different nuclear environments. The final section reviews recent developments which suggest several alternatives for correcting embrittlement or minimizing its effects in current reactors and possibly for avoiding it in future reactors. It is impossible to cover all aspects of radiation embrittlement of all reactor-vessel steels. Accordingly throughout the review, those aspects considered most important to the ultimate engineering use of the results are emphasized and supported by examples from experimental data.

Story, J. S.
see Hanna, G. C.: 41

Streltsova, V. N.
see Moskalev, Yu. I.: 68

Sulin, V. V.
see Berzin, A. K.: 10

93 Suschny, O. (International Atomic Energy Agency, Vienna (Austria)).
METEORITE RESEARCH.
Report on the International Symposium held in Vienna, Austria, 7-13 August 1968.
Conferences and Symposia.
Vol. 6, No. 3 (1968) p. 213-222.

Swallow, A. J.
see Nosworthy, J. M.: 72

94 Swindell, G. E., Taw, H. T. (International Atomic Energy Agency, Vienna (Austria)).
HANDLING OF RADIATION ACCIDENTS.
Report on the IAEA/WHO Symposium held in Vienna, Austria, 19-23 May 1969.
Conferences and Symposia.
Vol. 7, No. 3 (1969) p. 197-205.

Tarasov, V. A.
see Dubinin, N. P.: 27

Taw, H. T.
see Swindell, G. E.: 94

Tchernilin, Yu. F.
see Gilli, P. V.: 36

95 Teulade, P. (Lyon Univ., Villeurbanne (France). Lab. de Zoologie Expérimentale).
RECENT RADIOBIOLOGICAL EXPERIMENTS ON BOMBYX MORI.
Vol. 4, No. 2 (1966) p. 3-57. (In French)

Thanks to its physiological characteristics (embryonic diapause, synchronous gamete development) and its great genetic variability, Bombyx mori constitutes excellent material for studying the effect of ionizing radiations. Embryo. The use of numerous criteria (mortality, duration of embryonic development, and histological and biochemical analyses) has made it possible to follow the variations in radiosensitivity as embryogenesis proceeds. It has likewise been possible to distinguish the respective roles of diapause and of hibernation (particularly the effect of aging). Various studies of the embryo have further contributed valuable data on the effect of the mode of irradiation (dose fractionation and rate) and of LET, and have demonstrated the vital role of recovery. Gametes. The effect of ionizing radiations on the progress of gametogenesis has been tested by histological and genetic methods (particularly that of specific loci). Certain stages which proved to be extremely sensitive permitted the performance of very interesting experiments on the effect of the mode of irradiation and LET. The results obtained explain the processes of radio-induced mutagenesis and stress the extreme importance of recovery. Radiobiological studies have also contributed to our knowledge of the physiology of Bombyx mori.

96 Thamer, B.J. (Los Alamos Scientific Lab., N. Mex.).
THE CONTAINMENT OF LIQUID-METAL FUELS AT 500-1000°C.
Vol. 1, No. 2 (1963) p. 3-36.

Some corrosive effects are illustrated by observations in the area of metal coolants, particularly the alkali metals. This subject and the following areas are discussed: the containment of the Pu-Fe eutectic in tantalum; Pu-Ce-Co alloys in tantalum, niobium, molybdenum, and ceramics; Ce-Co alloys in tantalum; Pu-Ce-Ni and Pu-Ce-Cu alloys in tantalum, niobium, and molybdenum; U-Pu-Mn alloys in yttrium and ceramics; U-Mn eutectic in yttrium, tantalum, niobium, and ceramics; U-Cr and U-Fe eutectics in yttrium, tantalum, and niobium; Bi-U alloys in steels, graphite, tantalum, molybdenum, beryllium, and yttrium; Bi-Pu alloys in tantalum, niobium, and molybdenum; alloys of Al-U-Th in yttrium, tantalum, and niobium; Al-U alloys in yttrium, tantalum, niobium, and titanium; and Mg-Th alloys in tantalum and niobium. These subjects have been reviewed up to October of 1962.

Tshitenge, G.
see Evrard, C.: 31

97 Ulstrup, J. (Univ. of Denmark, Lyngby. Chemistry Dept.).
METHODS OF SEPARATING THE ACTINIDE ELEMENTS.
Vol. 4, No. 4 (1966) p. 3-82.

This article is a survey of the existing literature up to the early part of 1966 on the methods of separating the actinide elements. The survey is complete for all elements except uranium and plutonium which are only described generally because the literature on these two elements is very extensive. The methods of separation described are based partly on older principles such as fractional precipitation, distillation or sublimation and partly on more modern principles such as solvent extraction, ion exchange and various chromatographic procedures. Some of the latter have been developed specifically for the actinide elements. The information is arranged according to the actinide element rather than the method of separation, because the methods applied vary from one element to another and several methods are often used for the isolation of one particular element. Nuclear properties of the actinide elements are briefly mentioned where they are directly related to the actual method of separation; isotopic separations are not described.

98 Ursu, I., Lupei, V., Nistor, S. V. (Cluj Univ. (Romania). Solid State Physics Lab.).
ELECTRON SPIN RESONANCE STUDIES OF IRRADIATED SEMICONDUCTORS.
Vol. 5, No. 1 (1967) p. 97-138.

This article forms a review of electron spin resonance (ESR) studies carried out on various types of semiconductors. Short surveys of semiconductors and the ESR method are followed by results obtained with irradiated silicon, germanium, diamond, and compound semiconductors such as zinc sulphide and glasses.

99 Vaskov, L. S. (Radiobiology Inst., Sofia (Bulgaria)).
CLINICAL DIAGNOSIS AND THERAPY OF CHRONIC RADIATION INJURIES.
Vol. 2, No. 4 (1964) p. 59-94. (In Russian)

The review covers 270 books and articles published in recent years. Attention is paid primarily to the classification, causal mechanism and clinical picture of chronic radiation injuries, and to their differential diagnosis. Differences in the views of a number of problems relating to the pathogenesis of radiation injury are indicated. On the other hand, a description of biophysical, radiometric, autoradiographic and other special methods of diagnosing radiation injuries falls outside the prescribed scope of the review. The article reflects the present status of research as regards indices for clinical use and methods of treatment, a very limited assortment of which is all that is so far available.

100 Vereskunov, V. G. (International Atomic Energy Agency, Vienna (Austria)).
TREATMENT OF AEROSOLS AND VOLATILIZATION PRODUCTS DURING WASTE PROCESSING OPERATIONS.
Report on an Agency Panel held at Istanbul, Turkey, 12-16 December 1966.
Conferences and Symposia.
Vol. 5, No. 2 (1967) p. 173-176.

101 Westcott, C. H., Ekberg, K., Hanna, G. C., Pattenden, N. J., Sanatani, S., Attree, P. M. (International Atomic Energy Agency, Vienna (Austria)).

A SURVEY OF VALUES OF THE 2200 m/s CONSTANTS FOR FOUR FISSILE NUCLIDES.
Vol. 3, No. 2 (1965) p. 3-60.

A study of the most probable values of the 2200 m/s constants for the fissile nuclides ^{233}U, ^{235}U, ^{239}Pu and ^{241}Pu has been undertaken, using a least-squares fitting method. The various experimental data have been carefully reviewed, and the following values resulted.

RECOMMENDED VALUES FOR 2200 m/s CONSTANTS[a]

	^{233}U	^{235}U	^{239}Pu	^{241}Pu
σ_a	576.3 ± 2.3	679.9 ± 2.3	1008.1 ± 4.9	1391 ± 22
σ_f	527.7 ± 2.1	579.5 ± 2.0	742.4 ± 3.5	1009 ± 9
σ_γ	48.6 ± 1.5	100.5 ± 1.4	265.7 ± 3.7	382 ± 21
α	0.0921 ± 0.0029	0.1734 ± 0.0025	0.3580 ± 0.0054	0.379 ± 0.021
η	2.284 ± 0.008	2.071 ± 0.007	2.114 ± 0.010	2.154 ± 0.036
ν	2.494 ± 0.009	2.430 ± 0.008	2.871 ± 0.014	2.969 ± 0.023

[a] Cross-section values in barns (b).

A detailed discussion of the problems involved, especially in assessing the accuracy of the individual measurements and of the final output values, is given. The errors shown above are quoted as standard deviations, and include some allowance for possible systematic or non-random contributions to the errors of the original measurements that, although not identifiable in the input data, may nevertheless exist.

Westcott, C. H.
see Hanna, G. C.: 41

102 Wilson, J. (International Atomic Energy Agency, Vienna (Austria)).
NUCLEAR DESALINATION.
Report on the Symposium held in Madrid, 18-22 November 1968.
Conferences and Symposia.
Vol. 7, No. 2 (1969) p. 237-253.

Yagodin, G. A.
see Sinegribova, O. A.: 88

Yuan, H. C.
see Beswick, C. K.: 12

Yudin, N. P.
see Shevchenko, V. G.: 87

Zámori, Z.
see Lovas, I.: 60

Zaporozhets, V. M.
see Berzin, A. K.: 10

103 Zeldovich, Ya. B. (Akademiya Nauk SSSR, Moscow).
QUARKS.
Vol. 5, No. 2 (1967) p. 1-58.

The paper gives a general account of the theories in which elementary particles are regarded as systems consisting of simpler 'sub-elementary' units. After a historical survey, the quark hypothesis, according to which such sub-elementary units have fractional charges, is expounded. It is shown how this hypothesis, in agreement with experiment, explains the structure of the families of strongly interacting particles known at present, including the family of the baryons, to which the proton and the neutron belong. The electromagnetic properties and the decay and scattering of particles are also shown to be satisfactorily explained. A review of the experimental search for free quarks, with accelerators, in cosmic rays and in ordinary matter is given. It is pointed out that this work has not yet led to any definite conclusions about the existence of quarks. The theory of quark production in the collision of energetic particles and in cosmological conditions is described.

104 Zheludev, I. S. (International Atomic Energy Agency, Vienna (Austria)).
SYMMETRY IN PHYSICS. (A Lecture).
Special Item.
Vol. 7, No. 4 (1969) p. 215-264.

The symmetry approach to physical processes and phenomena has become popular in the past ten to fifteen years, the concept of symmetry being extensively used in crystallography, crystal physics, quantum physics and elementary-particle physics. A generalization of symmetry developed by the author and called complete symmetry is considered and applied to scalars, vectors, tensors and spinors. The application of conventional and complete symmetries to various physical problems is demonstrated.

Zheludev, I. S.
see Belov, V. F.: 9

105 Zuber, A. (Institute of Nuclear Research, Krakow (Poland)), Cameron, J. F. (International Atomic Energy Agency, Vienna (Austria). Div. of Research and Laboratories).
NEUTRON SOIL MOISTURE GAUGES.
Current Research and Development.
Vol. 4, No. 4 (1966) p. 143-167.

The theory is summarized and details are given of the theoretical and practical factors to be considered in selecting and using neutron soil moisture gauges. These factors include range of moisture contents to be measured, variations in soil and measurement parameters, methods of calibration and optimum measuring times. A comparison is made of some typical moisture gauge designs.

COMMEMORATIVE ISSUE (1966)

106 Cockcroft, J. (Churchill Coll., Cambridge (England)).
THE IMPACT OF ATOMIC ENERGY ON SOCIETY.
p. 7-14.

Predictions made at the 1955 Geneva Conference about the rapid development of nuclear energy have been realized. A summary of the trends in outputs and generating costs of different types of reactors is given. The obstacles in the problem of obtaining power by the fusion of hydrogen isotopes, together with the major advances made, are outlined. Among other subjects discussed are: the impact of nuclear energy on industrial practice; the possible relaxation of stringent reactor siting regulations; the use of reactors in the desalination of seawater; the application of radiation to food preservation and the sterilization of hospital supplies; the developments in important new tools for the physical sciences; and the impact of atomic energy on life sciences. The paper concludes with a summary of the achievements of international co-operation and the major role being played by the IAEA.

107 Emelyanov, V. (Akademiya Nauk SSSR, Moscow).
TRENDS IN THE DEVELOPMENT OF ATOMIC SCIENCE AND TECHNOLOGY.
Russian original, p. 75-79.
English translation, p. 81-84.

A brief account is given of the events which have taken place in world science and technology in connection with the peaceful atom since fission of the atomic nucleus was achieved more than a quarter of a century ago, and the trends of future development are considered. The basic fields of research dealt with and the practical work to implement and apply the results thereof, relate to nuclear power, radioactive waste disposal, the generation of power by nuclear fusion, the discovery of new analytical methods of detecting elements, research on high energy particles, the use of radiations and radioisotopes in industry for process control, in instrument manufacture, geology and archaeology, food preservation by radiation, nuclear ship propulsion plants, the use of nuclear energy to correct the course of spacecraft, and the desalination of salt water.

108 Gopal-Ayengar, A.R. (Atomic Energy Establishment, Bombay (India)).
ATOMIC ENERGY IN LIFE SCIENCES.
p. 59-71.

In surveying the impact of atomic energy on the life sciences, the author discusses particularly the various uses of isotopes in biology and biochemistry, instancing in some detail the effectiveness of tracers as a research tool. He touches on such subjects as the use of isotopes in revealing the processes of plant growth and nutrition, in eradicating insect pests, in improving agriculture and in promoting health and combating disease, and calls for a concerted effort to ensure that the great potential of atomic energy to benefit mankind is realized.

109 Gross, B. (International Atomic Energy Agency, Vienna (Austria)).
PRESENT AND FUTURE TRENDS OF SCIENTIFIC INFORMATION.
p. 85-96.

The growth of science and technology and their increasing influence on public life have led to new demands for information at different levels. The development of new information and communication techniques has created new capabilities. Neither the scientific community nor the information industry have as yet fully taken stock of the situation and so have not yet reached the necessary mutual understanding. The paper gives the picture of the situation as it is seen by a physicist who has recently been exposed to some of the new information techniques.

110 Leipunskii, A. (Gosudarstvennyi Komitet po Ispol'zovaniyu Atomnoi Energii SSSR, Obninsk. Fiziko-Energeticheskii Inst.).
NUCLEAR POWER SYSTEMS AND THEIR TECHNICAL POTENTIALITIES.
Russian original, p. 31-40.
English translation, p. 41-49.

Nuclear plants constitute a significant fraction of the electric power stations now under construction. The author assesses this position and surveys the considerable experience already gained in thermal reactors, particularly the PWR and BWR in USA, the GGR in England and France, the PWR and GBWR in USSR, and the heavy-water reactor in Canada. All these reactor systems can be perfected by raising the specific power, by improving and reducing the cost of fuel element fabrication and reprocessing, and by the introduction of superheating in the case of boiling water reactors. Considerable reductions in the fuel component of power costs can be expected from systems with improved neutron utilization: heavy water reactors and gas-graphite reactors with the graphite-based fuel elements. Fast breeders possess the important characteristics of being able to produce more plutonium than is burned up. Consequently, the fuel component is cheaper than in any other reactor types and is, to a large extent, independent of the cost of uranium. With fast breeders both expensive uranium and thorium can be used. When thorium is used, best results are obtained with a mixed cycle in which a mixture of uranium-233, plutonium and uranium-238 is used in the core and thorium in the blanket. Operating experience with fast neutron reactors using sodium as coolant, the development of sodium technology, and trials with fuel elements consisting of uranium oxide and plutonium oxide have shown that it is possible to design and build a fast neutron reactor capable of supplying power at lower cost than in any other system. At the start-up fast neutron reactors can be loaded with enriched uranium, which is then progressively replaced by the plutonium produced within the breeder reactor system. This is an economically attractive procedure. By the mid-seventies enough experience will have been gained with prototypes represented by the BN-350 reactor under construction at Shevchenko and the PFR at Dounreay for work to begin on constructing high-power, commercial fast breeders. By the end of the seventies we can expect the beginning of fast-breeder construction on a large scale, with reduced construction of thermal neutron reactors.

111 Lewis, W.B. (Atomic Energy of Canada Ltd., Chalk River (Ontario)).
POSTSCRIPT TO THE LECTURES.
p. 73-74.

112 Néel, L. (Commissariat à l'Energie Atomique, Grenoble (France). Centre d'Etudes Nucléaires).
FUNDAMENTAL RESEARCH IN NUCLEAR RESEARCH CENTRES.
French original, p. 15-22.
English translation, p. 23-29.

The author recalls that fundamental research, in the past rather modest in its demands, to-day requires considerable human and material resources. Because of the substantial resources at their disposal, the nuclear research centres are the organizations best equipped for fundamental and applied research in the atomic energy field. Among the areas of research in which the nuclear research centres play a role of prime importance, the author mentions nuclear physics and chemistry (particularly plasma physics and fusion), neutron diffraction (with special reference to cold neutrons of large wavelength), the effects of radiation on solids, and electronics. In his opinion the nuclear research centres, for reasons of safety and economy, are in the best position of all organizations engaged in nuclear research to manage the operation of reactors, particularly research reactors. The author stresses, finally, the positive results which have emerged from close collaboration between the nuclear research centres, the universities and industry.

113 Prado, L.C. do (Comissão Nacional de Energia Nuclear de Brasil, Rio de Janeiro).
OPENING ADDRESS.
p. 5-6.

114 Webster, W. (Yankee Atomic Electric Co., Boston, Mass.).
THE COMMERCIAL FUTURE OF NUCLEAR POWER.
p. 51-58.

The use of electric power in the world is increasing rapidly and this growth may be expected to continue for decades. As a result, a six- or eight-fold increase in generating capability must be provided for before the year 2000. It is anticipated that the bulk of future power supply will be based on nuclear and pumped-storage hydro stations. Nuclear power costs for large plants are now competitive in most areas of the world, and reactors are proving reliable and dependable. The flood of orders for major plants in the past year assures the pace of the program and will minimize the effects of a short-range setback if some plants under construction should be delayed or prove temporarily disappointing. There is no unanimity as to the best type of thermal reactor. It is anticipated that both water reactors and gas-cooled reactors will continue to be major factors and that other types will be worked on. All of these will become more economical and efficient, and appear in larger sizes, but type selection will continue to be influenced by matters other than relative efficiency and economy. The fast breeder reactor will probably break through to technical and economic feasibility around 1980 and then outrun the thermal reactor in rate of installed capacity. The exact pace of this program is less certain than the final picture. Probably by 1980 over half of the new capacity being built will be nuclear. It will be the main reliance for new central station plants after that. One may anticipate 200 000 to 250 000 megawatts of nuclear power by 1980 and 3- to 4-million megawatts before the year 2000. Towards the end of the century, one should anticipate an equilibrium situation which will be reached first in the more highly industrialized countries. Breeder reactors will be the backbone of the power supply, which will include thermal reactors with plutonium playing an important role as a balancing factor. These will be complemented by pumped-storage hydro plants. There will be a continuing use of fossil fuel plants and conventional hydro. The attainment of this situation will require a tremendous expansion of manufacturing capacity for providing plants and fuel, and separation facilities and other lines. It will call for major adjustments of many sorts, including the adoption of a full system of inspection and licensing; and for its fullest development, it may require financial and trade rearrangements. The author foresees it as leading to a great increase in joint efforts and cooperation and reciprocity between nations and believes this may be a major force for world integration and understanding.

SPECIAL ISSUE No. 1 (1966)

115 PLUTONIUM: PHYSICO-CHEMICAL PROPERTIES OF ITS COMPOUNDS AND ALLOYS

Editor: O. Kubaschewski

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M.H. Rand	I.	Thermochemical properties
D.T. Livey and P. Feschotte	II.	Phase diagrams
H. Nowotny and K. Seifert	III. III. 1.	Crystal structures and densities Compounds with non-metals
R. Ferro	III. 2.	Intermetallic phases

SPECIAL ISSUE No. 2 (1968)

116 NIOBIUM: PHYSICO-CHEMICAL PROPERTIES OF ITS COMPOUNDS AND ALLOYS

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P. Feschotte, D.T. Livey and O. von Goldbeck	II.	Phase diagrams
H. Nowotny and K. Seifert	III. III. 1.	Crystal structures and densities Compounds with non-metals
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